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CLOSET WALL PROJECT (LDRC)

Progress Report No. 2

Testing Program

Kapple 1952

LUMBER DEALERS RESEARCH COUNCIL

CLOSET WALL PROJECT

Progress Report of Phase 2

Testing Program

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LDRC CLOSET WALL PROJECT

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ABSTRACT

The shelf of a closet usually sits loosely on its ledge with only one function; namely to support hat boxes or whatever we choose to store thereon. Actually, there is no reason why it should not at the same time serve as a rib to stiffen the back and side walls of a closet. The shelf can stiffen the back wall, the back wall can stiffen the side wall, and the side wall can stiffen the shelf; thus achieving three-way-stiffening similar to the corner of a box. When we consider this form of stiffening, it becomes possible to use much lighter panels for the back walls and dividers in the closet. This report presents the results of building and testing new closet elements, designed to take advantage of this principal.

1. Wall Panel Tests

Concentrated, impact, and uniform load tests were made on twenty-two different 4' x 8' studless walls designed for the back walls of closets and comparable data on six different 4' x 8' stud walls. Four of the studless walls were hollow core, fifteen were double laminates, and two were plywood. Twenty studless and stud panels were modified or eliminated in exploratory tests, leaving four of each type to be tested on three specimen of each type.

The results showed that three of the new panels are well suited for use on the back wall of the closet four feet wide if fastened around the perimeter and at the shelf six feet above the floor. One was a 3/4 inch thick double laminate of gypsum board and the other two, named "thin-wall", were different grades of hardboard laminated to gypsum board of different

thicknesses. The weakest point of all three types of laminated wall panels were both stronger and stiffer than the weakest part of the nonload-bearing stud walls finished with 3/8" gypsum board. The material for these laminated panels cost 21% to 44% less and weighed 31% to 48% less than stud walls finished with 3/8" gypsum board.

E. Working Model Tests

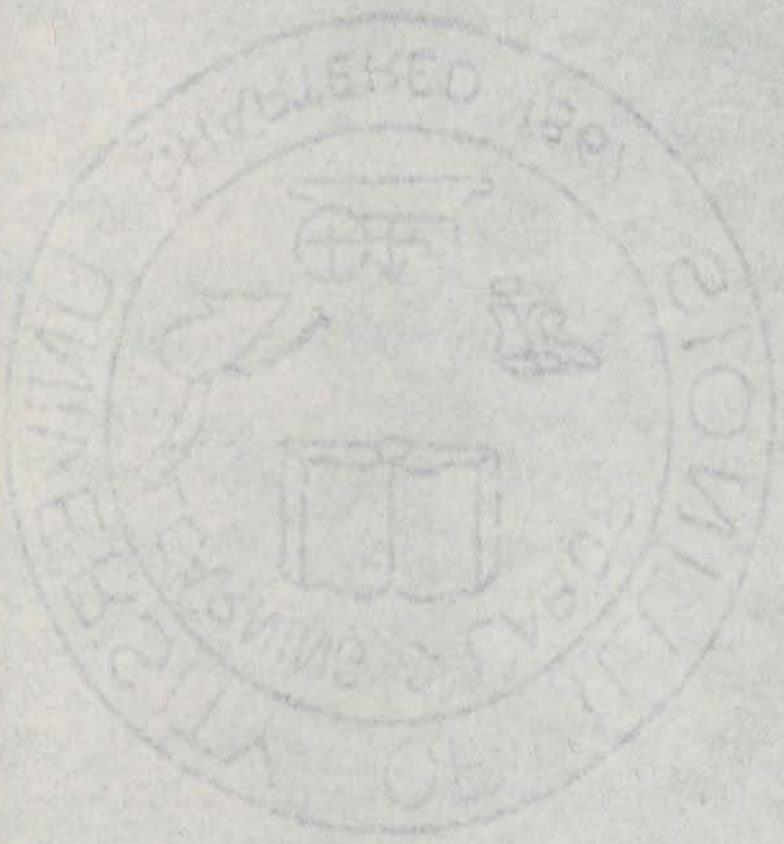
After the panel tests, two working models 12'-0" wide were built to check the structural feasibility and impact resistance of the complete closets made with thin-wall back panels and various divider panels made of a sheet of hardboard reinforced with various types of perimeter framing.

F. Recommended Closet Wall Construction

The final selection of the back panel to be used is left to the discretion of the designer and builder; however, the reserve strength of the thin-wall panels, made of 3/8" gypsum board laminated to 1/8" untempered hardboard, will reduce the possibility of damage during construction. We have accordingly recommended this panel in our working drawings for closet walls.

In order to capitalize on the economy of this new laminated back wall, three more basic elements of the closet were also designed of economical and space saving construction, they are; 2' x 8' divider panel, the end wall panel, and the multiple shelf unit. The latter is 16" deep, ranging in width from 16" to 32" and extending from floor to ceiling. These elements may be combined with the thin-wall panels to form closets of any width provided the divider or shelf units are located to support the edges of the thin-wall panels with a maximum spacing of 4'. The walls and shelves built from these units require less space and are more economical

than the conventional stud wall closet. For instance the walls and shelves of a thin-wall closet 12' wide with a single shelf, the same as a stud wall closet, reduces the cost 15%, or as designed with four times the shelf space it can be built for the same cost as a stud wall closet.



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GLOSSARY

Damage - Cracking of any part of element cover which can be concealed by patching without replacing cover material, i.e. cracks that can be patched with putty or paint.

Element - Any floor, wall, partition, ceiling or roof.*

Element Covering - Any material or combination of materials spanning between structural members or ribs. It does not include applied protecting for wearing coverings such as paint, linoleum, roofing, etc.*

Failure - Cracking or breaking of any piece of the specimen that affects the strength of the construction, i.e. cover material or ribs must be replaced in order to restore original strength and appearance.

Flimsy - Lacking stiffness to the extent that element vibrates visibly under light impact such as touch of the finger.

Residual Deflection and Set - Deflection remaining after removal of load. It is computed by determining the difference between the initial reading before any loads are applied and the reading taken after each load is removed.

Rupture - A breaking apart which leaves surface each side of cracks in different planes.

Set - The residual deflection remaining after removal of load.

Thin-wall - Laminated panel made from 4 x 8 sheets of gypsum board and hardboard cemented together.

* As defined in HHFA 1947 Performance Standards.

I - CONSTRUCTION BACKGROUND

A - Design and Construction of House Influences the Closet

The use of clear span construction with trusses or deck and beams has more than speeded up the construction of the house roofs. It has relieved the interior partitions of their functions as bearing walls. Every day open room construction grows more popular in residential construction. Even the small builders can now benefit from this system which quickly protects most of the construction materials and operations from the delays and damage of bad weather.

Simultaneous with this development the closet wall has become increasingly popular. To date, these units have been too expensive for the large volume house building market; hence, the Lumber Dealers Research Council gave the Small Homes Council a research grant to study the development of a system for the construction of low cost closet walls.

This program specified that the construction should be suitable for small scale as well as large scale operations. Only non-critical materials which were readily available through normal building channels were to be used, and the construction of the closet walls should require only standard house building tools.

B - Double Walls Are Extravagant

Cost studies of the production costs of the walls and shelves of the closet walls built in the 30-unit Staff Housing Project by the University of Illinois in 1949 showed that pre-cutting and pre-assembly of closet walls and shelves does not guarantee low cost construction. In fact, the double side walls, floors and ceilings of these and other closet wall units are an extravagance. Further study indicated that it should be possible to

save a considerable amount of money by using the regular house construction for ceilings, floors and side walls; thereby reducing the components to be pre-cut and pre-assemblied to the front, back, divider panels, shelves and in a few cases, end walls.

C - Improved Closet Fronts Available

Our study of commercially available materials soon revealed that manufacturers have already developed a great variety of well designed "full access" closet fronts which exceed the quality of the conventional door-in-wall, and in many cases are less expensive. Figure 5-12 shows that the folding door can reduce the cost of the closet front 42% and the sliding door can save 32%. On the other hand, the walls and shelves of manufactured closet-wall units are more expensive than the conventional stud wall closet, therefore this project concentrated on the development of an improved and economical system for building the walls and shelves of closets.

II - DESIGN REQUIREMENTS

A - Complete Closet

1 - Space Requirements

Progress Report No. 1, Phase A reports the space requirements for various closets throughout the house. Although the testing program originally concentrated on the development of a bedroom clothes closets, it was later expanded to provide elements which would meet the space requirements for most of the functions specified in that report.

All of these space needs have been translated into three major elements. Although the dimensional requirements for each of these spaces varies with the function, it has been possible to establish the following range of sizes which will satisfy most of the storage requirements for house construction.

Hanging or Bulk Storage

Hanging and bulk storage space is required for clothes, sports, hobbies, and cleaning equipment. Such space meets the majority of these requirements if it is 5' 6" to 6' high and can generally be divided into compartments 2' to 4' wide.

Shelves and Drawers

Shelves and drawers within the scope of this study are required for clothes, linen, and cleaning equipment. Multiple shelf and drawer units to meet these requirements should be of the following sizes:

16" to 32" wide
16" deep
Each compartment 3" to 24" high
Whole units 3' to 8' high

Shelves Above Bulk Storage

A 12" wide shelf 5½' to 6' above the floor has been the standard for clothes and cleaning closets. Our studies reveal that two shelves are far more useful with a lower shelf 16" deep and an upper shelf 1' higher, that is 12" deep.

2 - Site Fabrication

The program specifies that the construction must be economical and practical for small scale as well as large scale operations. Our previous experience on framing indicates that pre-cutting and pre-assembly, before erection, improves the efficiency of the labor because it allows the carpenter to work on a jig-table with both feet on solid ground instead of standing on a scaffold or a ladder. Also cutting schedules and pre-cutting which go along with this type of operation greatly minimizes the time lost in measuring and fitting lumber. This same technique of pre-cutting and pre-assembly has been established as an objective for the design of the improved closet wall. However, it should be possible to do any of the operations with standard carpenter tools and using standard building materials. In order to make sure that the work does not become cumbersome it was important to limit the size and weight of each pre-assemblied element so that it can be easily handled by one man.

3 - Modular Coordination and Flexibility

Standardization is always inclined to reduce the flexibility of design. On the other hand, minimizing the number of elements and standardizing their dimensions in accordance with the principals of modular coordination makes it possible to save money and achieve flexibility even though the units are standardized.

4 - Avoid Over-Engineering

All of the wall finish materials which are customarily applied over stud walls are weaker than the studs themselves and the studs are far stronger than is necessary to withstand the normal occupancy loads for non-bearing partitions. This excessive strength of studs provides the clue for economy in closet wall construction.

To date, the closet shelf has been considered to be an element of trim, whereas it can actually serve as a rib to stiffen the back and side walls of a closet. The shelf stiffens the back wall, the back wall stiffens the side wall, and the side wall stiffens the shelf; thus achieving three-way-stiffening similar to the corner of a box. When we consider this form of stiffening it becomes possible to use much lighter studless panels for both the back walls and the divider panels between closets.

5 - Cost Limitations

Many manufactured closet fronts are more economical than the conventional stud wall closet front with hinged doors. It is the purpose of our program to achieve this same degree of improved quality, while reducing the cost of the walls and shelves for the closets. The Small Homes Council has conducted many cost studies on previous projects and thereby accumulated labor and material factors which are suitable for estimating and comparing the costs of conventional stud wall closets versus the newer types of construction. Wage rates and dealer to contractor material unit prices which prevailed in the area as of summer 1951 have been used in all cost estimates.

B - Back Wall Panel

1 - Element Size

Since it is possible to divide the hanging or bulk storage space in closets into compartments ranging in width from 2' to 4', wall panels 2' to 4' wide and 8' high are suitable for the back wall of closets. The 4' x 8' size is ideal since it makes it possible to use full size sheets of wallboard for the construction of back wall panels.

2 - Structural Connections

In order to achieve maximum efficiency in using the wall panel, it is necessary to connect the panel with the floor, side walls, ceiling and shelves. Nailed connections have been used throughout so that the construction can be handled by carpenters without special tools.

3 - Cost Limitations

The cost saving objective of this program requires that the finished panels be less expensive in place than a stud wall. Since it would have been virtually impossible to estimate the labor cost on the brand new panels prior to their construction, a limitation on the material cost was established. There are over one hundred varities of interior wallboard which might be used for closet wall construction. When considering all of the possible mastics and reinforcing as well as the various combinations of different wallboard, virtually thousands of wall panel designs can be imagined.

The first step was to check their cost. The cost of the conventional 2" stud wall finished with 3/8" gypsum board was used as a basic cost and the new studless wall panels were considered only if the material costs

saved 20% or more. Although the labor cost was not estimated it was important to plan for labor savings. This was done by planning for pre-cutting, pre-assembly, lighter weight construction, and fewer pieces of material per component.

4 - Strength Requirements

The HHFA Performance Standards of 1947 were tentatively selected as a basis for evaluating the strength and stiffness of the new wall panels. These standards specify the limits for deflection and set, and prescribe the loads which must be sustained without failure under concentrated, impact and uniform load tests.

Since none of the panels, tested and reported by the Bureau of Standards under their "Building Materials and Structures" series, qualified under the HHFA 1947 Performance Standards it was considered advisable to test conventional 2" and 4" nonload-bearing stud walls in order to provide an alternate yardstick for evaluating the stiffness and strength of the new studless walls.

Building Code compliance was another important consideration. Most codes which stipulate strength or stiffness requirements for nonload-bearing partitions usually specify uniform load requirements. Although the codes vary, the specified design load is usually between 5#/sq. ft. and 15#/sq. ft. Hence it is also important to compare the uniform load resistance of the new panels with these building code requirements.

5 - Esthetic Standards

Another objective of this program required that the finished wall panels be esthetically acceptable for the large volume house building

market. Smooth and rigid plaster walls have long been accepted as the ideal surface for interior finish within our own country. Other countries such as Japan have been completely satisfied with light weight walls of rough textured finish. Although future developments may arouse public interest in new types of light weight colorful panels, for the time being it seems wisest to use standards which are based on the esthetic characteristics of currently popular construction; hence the following physical requirements were established:

The weakest part of the finished wall must be as stiff under daily occupancy loads as accepted conventional construction. Gypsum board dry wall on studs was used for test comparisons.

The walls must be capable of a smooth surface finish on the outside of the closet but not necessarily on the inside of the closet. Walls requiring "V" joints, ribs and raised or sunken panels were avoided.

C - Divider Panel

1 - Element Size

The hanging or bulk storage space must be at least 1' 10" deep from the inside of the closet front to the back wall, in order to allow adequate space for hanging clothes. Each different type of closet front requires different thickness for the clearance of the stacked or sliding doors. Our studies, based upon the use of either a folding or sliding door, showed that a depth of 2' 1" from the face of the closet to the inside face of the back wall will leave the required 1' 10" clearance. Hence a panel 8' high and at least 2' 1" wide is adequate in size for a divider or end wall panel.

2 - Structural Connections

In order to provide for reinforcing, the panel must be designed for nailing to the floor, ceiling, and shelf. It must also have a nailing surface 1-1/2" wide on the back in order to provide a 3/4" nailing surface for each of the connecting back wall panels. One shelf strip must be fastened 5-1/2' to 6' above the floor in such a manner as to provide a structural connection between the divider panel and the shelf. Connections for an upper shelf are optional and would not necessarily be required in all closets.

3 - Cost Limitations

As in the case of the back wall panels, the cost was limited by checking to see that the material costs did not exceed 80% of the cost for an equal sized conventional stud wall finished with 3/8" gypsum board. Economy of labor was planned by reducing the weight of the construction, the number of pieces of material involved in the wall panel and designing for pre-cutting and pre-assembly.

4 - Strength Requirements

Since the divider panels are partially protected from occupancy loads by the contents of the closet, such panels will be subjected to less severe loads than the back wall panels. However, it is important to check the strength of the divider panel in a completed working model to determine:

That the connections are capable of developing the full strength of the back wall panel.

That any part of a free standing divider panel will be able to sustain the same load as the weakest part of the back wall panel.

III - TEST PROCEDURE

A - Selection of Tests

To determine the structural properties of the various elements in the proposed closet construction, the standard tests and basic procedures as outlined in Building Materials and Structures Report No. 2 and A.S.T.M. Des. E72-47T were adopted. The method of testing nonload-bearing partitions of the type we contemplated in our closet wall indicated that a concentrated load test and an impact load test should be included as standard tests in our program. It also appeared advisable to include a uniform load test since most building codes specify uniform load requirements for partitions of this type.

From the outset, our testing program was geared to parallel the 1947 requirements of the HHFA Performance Standards. This necessitated variations in the basic tests and procedures of B.M.S. 2, particularly in the case of a concentrated load test. The variations from standard procedure are outlined in detail under the Description of Tests.

B - Test Sequence

In general, the various test specimen were tested in the following sequence:

The concentrated load test was first applied at the weakest point of the element covering. The specimen was then observed under the uniform load test. Finally the panel was subjected to the impact load test. All three tests were applied to the same face of the specimen.

The above sequence deviated materially from the standard procedure of B.M.S. 2 for nonload-bearing partitions in which the specimen received the

impact load test prior to the application of the concentrated load test. In scheduling our test sequence, an attempt was made to utilize the specimen under the three test loads without materially affecting results of one test caused by damage during a previous test. Since we were not testing our specimen to failure, it was quickly ascertained that the localized concentrated load had little or no effect on the results of the subsequent uniform load test. In addition, the uniform load had materially no effect on the results of the relatively heavier impact loads.

C - Specimen and Support

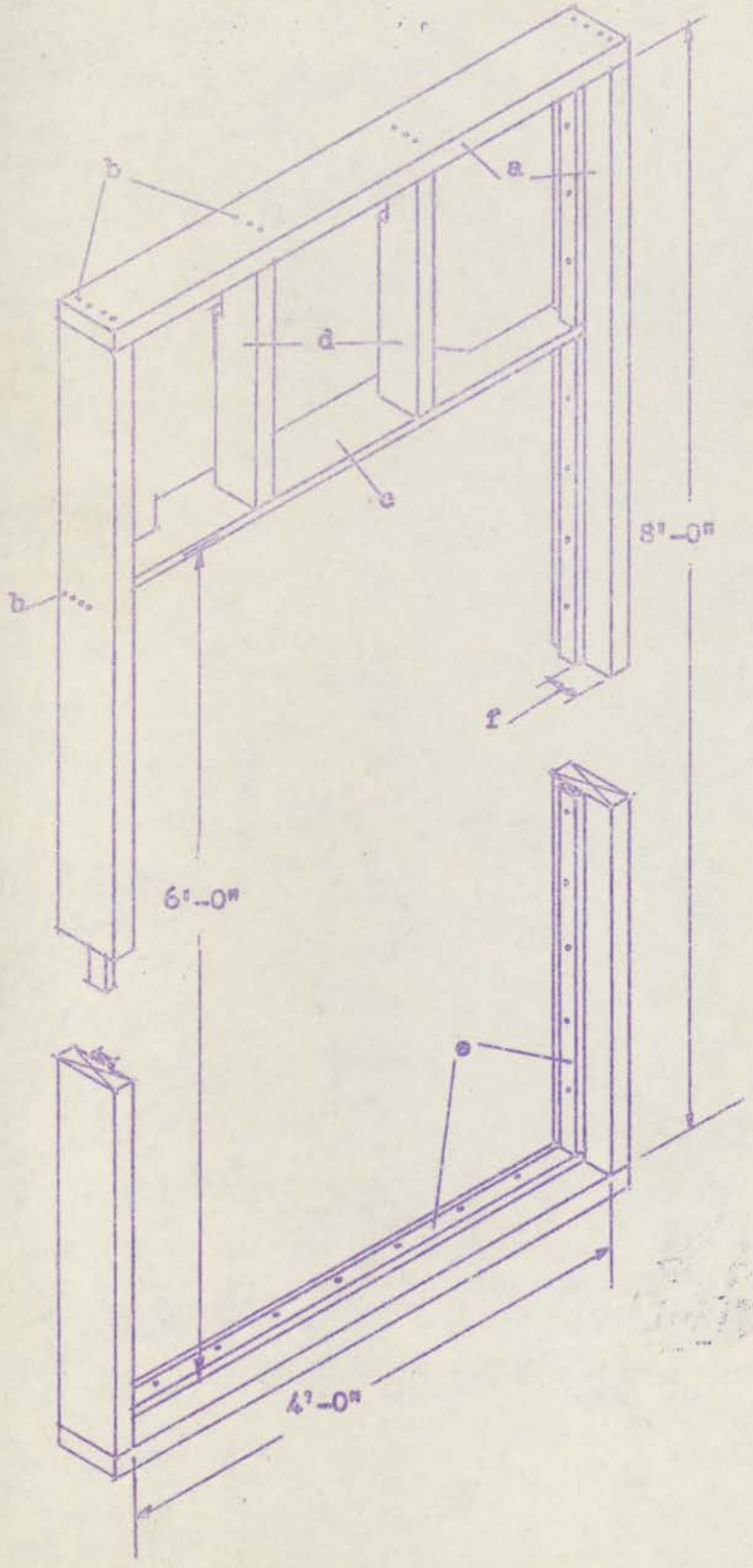
A description of each test specimen including materials and methods of construction can be reviewed in the Appendix.

The method of supporting the specimen under the three different test loads requires some explanation. Under the concentrated load test the stud wall specimen were tested on a platform G, Figure 3-2 which supported the element as a whole but allowed deflection of the element cover. For the uniform and impact load tests the stud wall specimen were tested as simple beams with a 7' 6" span utilizing roller C and knife edge B supports, Figure 3-6.

The laminated and hollow core panels were nailed to a 1" x 2" strip around the edges and to a shelf strip 6' from one end. These perimeter and shelf strips were fastened to a 2" x 6" frame, Figure 3-1. Under the concentrated load the 2" x 6" frame was allowed to rest on the platform G, Figure 3-2. This photograph shows a laminated panel receiving an actual test load. To observe the laminated and hollow core specimen under the uniform and impact test loads, the test frame and specimen were moved to the concrete

FIGURE 3-1

TEST PANEL FRAME FOR STUDLESS WALLS



a - 2" x 6" Douglas Fir

b - 16d common nails

c - Shelf strip, 1 x 6 #1 Yellow Pine nailed through frame "a" and to 2 x 4's "d"

d - 2 shelf strip stiffeners, Douglas Fir 2 x 4's 16" o.c., end nailed through top frame member and shelf strip

e - 1" x 2" perimeter strip nailed to 2" x 6" frame with 8d common nails 6" o.c.

f - Dimension equals panel thickness

FIGURE 3-2

LAMINATED SPECIMEN RECEIVING CONCENTRATED LOAD TEST

B - Steel cylinder
D - Dial micrometer
E - Weighted cylinder (40#)
F - Weighted cylinder (50#)
G - Platform support
J - Test frame
K - Laminated specimen

FIGURE 3-6

STUD WALL SPECIMEN - IMPACT LOAD TEST

A - Stud wall specimen
B - Knife edge supported
C - Roller support
D - Sand bag
E - Height indicator


AA-1

block platform and nailed securely in place to prevent rebound and vibrations during the impact test loads, Figure 3-4.

The test frame was devised in an attempt to simulate the support the specimen would receive in a closet. The load was applied so as to position the panel toward the supporting perimeter and shelf strips. This would be the equivalent to a load on the back of a closet. A limited number of impact tests were also made on the other side, of a fully laminated panel, in order to get data on the resistance to loads from the inside of the closet.

DESCRIPTION OF TESTS - 4 x 8" SPECIMEN

D - Concentrated Load Test

1 - Loading: In an attempt to compare the results of the concentrated load tests on our panels against the requirements of the 1947 HHFA Performance Standards, the concentrated test loading procedure was altered materially. Instead of applying increment loading to the weakest point as in B.M.S. 2, the design load of 40# and an increment 2½ times design load of 90# was adopted for purposes of comparison with the 1947 requirements. The residual indentation after the load was removed was measured as well as the indentation under load. This was necessary for comparison with the HHFA Performance Standards.

A steel cylinder B, Figure 3-3, 1" in diameter, was placed on the face of the specimen at the weakest point of the element covering. The loads were applied by lowering one or both of the hollow steel cylinders weighted with lead and designed to engage each other, Figure 3-2. By a system of pulleys, cylinder E weighing 40# was lowered into the receiving end of the steel cylinder B until the full 40# load was applied through the cylinder

FIGURE 3-3

CONCENTRATED LOAD APPARATUS

A - Stud wall specimen
B - Steel cylinder
C and D - Dial micrometers
E - Weighted cylinder (40#)
H - Gage blocks

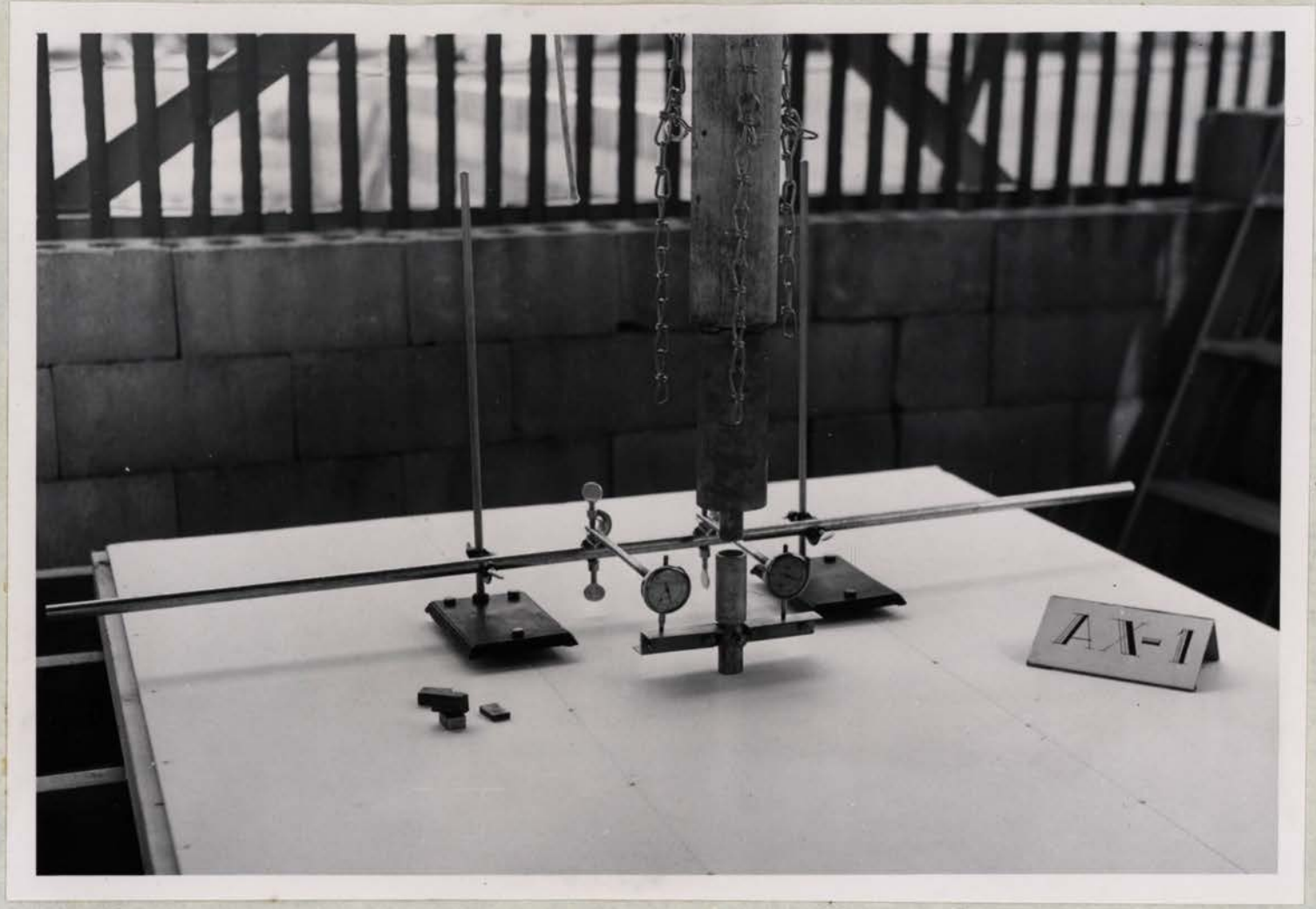

AX-1

FIGURE 3-4

LAMINATED SPECIMEN RECEIVING UNIFORM LOAD TEST

A - Laminated specimen in test frame
B - Sand stop
C - Scale


½" GYPSUM LAMINATED
TO ⅛" HARDBOARD

to the specimen. After readings were recorded, the load was removed for the residual deflection reading. Then cylinder E and F were lowered together, thereby applying a total of 90# through the disc to the specimen. Again the load was removed for the residual deflection reading.

It was obvious that results under only two loads were of limited values. Although this data will not provide the basis for drawing a graph for the performance curve under deflection and set, it is useful for the purpose of comparing the stiffness of different types of panels and for determining whether or not failure results under the two test loads.

2 - Apparatus: To measure the deflection and residual deflection, at the axis of load, two dial micrometers C and D, Figure 3-3 were employed in contact with a flange recessed into cylinder B. The micrometers were graduated to 0.001" and readings were recorded to the nearest division. To compensate for error due to the tipping of the cylinder B, the readings of each dial micrometer were averaged and the mean recorded as the final reading.

3 - Results: The deflection was recorded as the difference between the initial reading taken before the load was applied and a reading taken when the application of the load had apparently caused the maximum deflection. This was usually 3 to 5 minutes after applying the load. Residual deflection was recorded as the difference between the initial reading and a reading taken after the load had been removed. Throughout the testing, the specimen were inspected carefully for any signs of damage or failure. The results of the concentrated load test have been recorded graphically and can be reviewed in the Appendix. Observations of damage and failure are

also reported in the Appendix.

E - Uniform Load Test

1 - Loading: The HHFA Performance Standards specify the stiffness and strength requirements for wall panels under a 15# and a 33-3/4# per square foot uniform load.

Transverse loading at the quarter points, which is the customary method of loading for this test, could not be used to test the studless wall panels supported on four edges. It was, therefore, necessary to use a load which would remain effective whether the panel deflected on one or two axis. Application and spreading of sand was well suited for this purpose; however, this procedure made it impractical to remove the increment loads in order to obtain set readings. Sand was weighed and loaded onto the specimen in increments of 5# per square foot to a total of 35# per square foot, Figure 3-4. After each increment of load was applied, the sand was leveled until a uniform depth of sand blanketed the specimen.

2 - Apparatus: To measure the deflection of the specimen under the uniform load, a deflectometer, Figure 3-5 was employed. The deflectometer consists of a metal tube B, screwed into a three legged stand A. A steel rod E is set inside of the tube B and held by the friction clamp D. The rod is placed in contact with the unloaded face of the specimen located at the weakest point of the element. As the specimen deflects under load, the rod is forced down into the metal tube.

To measure the set, a set gauge Figure 3-7 was used. The gauge, consisting of a three legged tubular frame C and a dial micrometer F attached to the tube at the desired location, was placed on the unloaded face of the specimen.

FIGURE 3-5

DEFLECTOMETER

A - Three legged base
B - Steel tube
C - Scale
D - Friction clamp
E - Graduated steel rod

FIGURE 3-7

LAMINATED PANEL - IMPACT LOAD TEST

A - Test frame
B - Laminated specimen
C - Three legged tubular frame
D - Sand bag
E - Deflectometer
F - Dial micrometer

The micrometer was graduated to 0.001" and readings were recorded to the nearest division.

3 - Results: By measuring to a fixed line on the rod E, Figure 3-5 before and after a load is applied the deflection may be recorded as the difference of the two readings of the deflectometer. A steel scale C calibrated in one sixty-fourth of an inch was used and readings were recorded to the nearest division.

Residual deflection could not be measured with the set gauge, Figure 3-7, until the final load had been applied and removed. Throughout the testing, the specimen were under constant surveillance in an effort to observe damage or failure. The results of the uniform load test have been recorded graphically and can be reviewed in the Appendix. Observations of damage and failure are also available in the Appendix.

F - 60# Impact Load Test

The 60# sand bag tests on the stud wall specimen conformed with the standard test procedure recommended by the Bureau of Standards* and the American Society for Testing Materials.** The studless panels were tested in the same manner, but were supported on four sides as previously described.

1 - Loading: An impact load was applied to the specimen by dropping a sand bag weighing 60# D, Figure 3-6, at the weakest point of the element, not the element cover. The bag was constructed of leather in strict accordance with the specifications outlined in B.M.S. 2.

The bag was dropped from successively higher increments of 6" until excessive damage occurred or until the limits of our testing apparatus was reached.

* Building Materials and Structures Report B.M.S. 2.
** Tentative Methods of Conducting Strength Test of Panels for Building Construction A.S.T.M. E72-47T.

The lifting and releasing of the sand bag was accomplished by threading a rope, attached to the bag, thru two pulleys and fixing the free end to a trigger. Upon releasing the trigger the bag could be dropped from any desired height.

2 - Apparatus: To measure the instantaneous deflection of the specimen, readings were made on the bottom surface of the panal at the axis of impact with the deflectometer, Figure 3-5, described under the uniform load test. The set was measured on the top surface at the axis of impact by the set gauge, Figure 3-7, also described previously under the uniform load test.

3 - Results: The deflection was recorded, after each successively higher drop, as the difference of the initial reading of the deflectometer before the bag was dropped and the reading immediately following the drop. Set was also measured after each drop. It was recorded as the difference between initial reading of the set gauge before the bag was dropped and a reading following the drop. Throughout the test the specimen were under constant surveillance to observe damage or failure. The results of the 60# impact load test have been recorded graphically and can be reviewed in the Appendix. Observation of damage are also available in the Appendix.

G - 15# Impact Load Test

The standard 60# impact load test has proven satisfactory for testing floor and roof panels also for testing stud wall panel framing, but it is to heavy to obtain adequate data for currently accepted types of light wall construction. In many of the tests conducted by the Bureau of Standards, the 6" drop of the 60# sand bag caused failure in the facings and for several constructions the bag completely shattered the facings even at

moderate heights of drop. Thus the weight of the sand bag was reduced to 15# in order to provide a better basis for evaluating the stiffness and strength of wall covering materials for interior partitions.

1 - Loading and Apparatus: The entire 15# impact load test procedure parallels the 60# impact load test procedure throughout, except that the load was applied at the weakest point of the element covering instead of the weakest point of the element. This did not change the method of testing the laminated panels, but two changes were made in the stud wall and hollow core panel tests. First the load was applied midway between ribs, and second the deflection readings were made on the bottom face of the loaded wallboard. This required cutting a small hole in the unloaded face of the wallboard.

2 - Results: The results of the 15# impact load test have been recorded graphically and can be reviewed in Appendix 1. Observations of damage are also available in Appendix 1.

H - Working Model Tests

After completion of the panel tests, working models were built to test the best wall panel as well as some newly designed divider panels. Two closets of three compartments each were built and the 60# sand bag swung against various parts of the closet.

The bag was suspended on a rope fastened to the ceiling adjoining the panel. First the rope supporting the bag was adjusted so that the center of gravity was opposite the point to be tested. The bag was then swung back until it raised 3" and then released. The bag was caught on the rebound to avoid additional blows. The deflectometer was placed in contact with the rear surface of the panel directly in line with the center of impact, Figure 3-8. Readings were made to the nearest sixty-fourth of an inch before and

FIGURE 3-8

MEASURING DEFLECTION ON WORKING MODEL

A - Hardboard side of laminated panel
B - Steel scale
C - Deflectometer

after each impact so as to determine the deflection and set. The tests were continued with successively higher drops until the panel failed or up to the limit of 36", Figure 3-9.

The 5' arc for the impact was smaller than is generally recommended; however, it is the maximum that was possible for the working model installed in a run with an 8' ceiling.

These tests served two purposes, first they provided a check on the validity of the data obtained on the horizontal panel tests. Second, they established the strength and stiffness of the newly designed free standing divider panels.

The impact was applied at five different points on each working model. The deflection and set was recorded for each impact and observations of damage were recorded. See Appendix pages 93 to 109.

FIGURE 3-9

SWINGING SAND BAG TEST ON WORKING MODEL

A - Back wall of compartment 2
B - Height indicator
C - Swinging sand bag

IV - DESCRIPTION OF WALL PANELS

A - Studless Wall Panels

Eight different kinds of wallboard were used on the twenty-two different types of studless walls that were built and tested under the single specimen exploratory tests. Drawings and descriptions of each panel are shown in the Appendix. Five of the panels were hollow core, fifteen laminates, and two plywood.

These 4'-0" x 8'-0" panels were designed so they could be laminated before erection. For instance, one of the panels was made by spreading 3# of taping cement on a sheet of gypsum wallboard. After the mastic was spread, the top layer was put in place. Each new panel was built on top of the other, and finally the top panel was loaded with sheets of wallboard or whatever building material was convenient until a total load of at least 15#/sq. ft. was applied. The panels were then allowed to set at least 24 hours under pressure. Before testing each studless panel, it was nailed to the 1" x 2" perimeter strip around the inside of the testing frame, Figure 3-1, and to the 1" x 4" shelf strip set 6'-0" from one end of the frame; thus simulating a panel equivalent to the back wall of a closet that is nailed at the sides, floor, ceiling and shelf.

The laminated panels made from gypsum board on gypsum board and gypsum board on hardboard were selected for the final tests. Under this part of the program, three specimen of each type of panel were built and tested.

B - Stud Wall Panels

Six different types of stud wall panels were also built. Drawings and descriptions of each panel are shown in the Appendix. These 4'-0" x 8'-0"

stud wall panels were constructed with studs 16" and 24" on center, top and bottom plates and finished on both sides with interior wallboard. Four different wallboards were tried on the stud walls. 3/8" gypsum board and 1/2" fiber board were selected for the final tests. Under these tests, three specimen of each type of panel were built and tested using both finish materials on 2" and 4" stud walls. The 2" stud walls used full size studs turned flat to simulate the conventional non-bearing partition which is accepted throughout the country for residential construction.

C - Working Model

After tests have proven the value of the thin-wall panel made by laminating gypsum board to hardboard, two working models were built. Drawings and descriptions of each working model are shown in the Appendix. Each working model had three compartments. The back walls were made of 1/2" thin-wall panels and each of the two divider panels in both models were of different design. The working model was nailed to concrete floors and gypsum board side walls and ceilings which were backed with dimensional lumber framing.

V - CONCLUSIONS

A - Evaluation of 4' x 8' Studless Panels

1 - Exploratory Tests

(a) Eighteen studless panels eliminated.

Two hollow core panels were made by gluing wood scrap between two sheets of gypsum board, one used 2" scrap and the other 1" scrap. The panel with the 1" scrap failed from a 6" drop of the 60# sand bag because the sharp corners of the blocking punctured the wallboard. The panel with the 2" scrap came apart before it was submitted to any tests. Both of these panels were too tedious to build and the blocking between panels increased the likelihood of damage from impact. One panel with wood lath ribs 6" oc and two different panels with 1 x 4's 24" oc were also tested as possible hollow core panels. Although these panels were adequate, the ribs added nothing to the strength of the two sheets of gypsum board, and did not add enough to the stiffness to warrant the extra labor and material cost. Hollow core panels were accordingly eliminated from further consideration.

Both 1/2" and 5/8" plywood panels were tested during the exploratory stage and proved to be strong enough but were not as stiff as desired. Since these panels cost more than the material for a conventional stud wall and since they did not develop stiffness characteristics any greater than less expensive panels, they were dropped from further testing.

In order to satisfy the stiffness requirement a triple laminated panel made from gypsum lath with gypsum board on each side was tested. The panel proved stiff enough under both the concentrated and impact loads but it weighed 172#. This is almost twice the weight that can be easily set in

place by one or two men. With such a heavy panel there is too much risk of breaking off the corners of the wallboard; therefore this panel was eliminated after only one set of tests.

Chicken wire reinforcing between two sheets of gypsum board has already been proven as a good means of increasing the fire ratings for laminated gypsum board construction. However, the panel that was built came apart before it was ever submitted to any tests. In view of the extra labor involved no further trials were made to develop the proper method of lamination.

It soon became apparent that laminated panels made with two sheets of wallboard were equal to or stronger than hollow core or reinforced laminated panels. Five different materials all fell within the price limits of our study. They were 3/8" and 1/2" gypsum board, 1/2" fiber board and 1/8" standard or tempered hardboard. After testing various combinations, it became apparent that fiber lacked the required stiffness and tensile strength; gypsum board had the necessary stiffness but had relatively small resistance to impact. Hardboard resisted impact well but lacked stiffness.

(b) - Laminated Panels Modified

The first double gypsum board panels were laminated with wallboard cement, and the first gypsum board to hardboard panels were laminated with cold setting glue. Both of these mastics proved satisfactory but the cost of application especially for the cold setting glue was too much. In order to reduce this cost, linoleum paste was finally selected. The first panels, using 3/4 to 1 quart of linoleum paste per 32 sq. ft., were too weak. Separation of the panels after testing showed that the linoleum cement bonded only about one-fourth of the surface. When the quantity of linoleum paste

was increased to 1-1/2 or 2 quarts per 32 sq. ft. panel, a complete bond was developed and the panels proved to be equally as stiff and strong as panels laminated with the other mastics.

The first 6 thin-wall panels were nailed to the perimeter frame and shelf strip with 4d box nails. The nails on one of these panels were pulled as a result of a 30" drop from the 60# sand bag and this weakened the panel for future drops. See Appendix page 42. Thereafter 6d nails were used and none were loosened by impact on the top surface. In fact, the 4 panels tested with impact on the back surface, Appendix pages 86, 87, 91, and 92 withstood impacts from drops of 2-1/2' before showing signs of damage other than loosening of nails.

The exploratory tests indicated that laminated panels made with two sheets of 1/2" gypsum board might be stronger and stiffer than was necessary. We therefore, decided to also test laminated gypsum board panels made with 3/8" gypsum board.

The strength and stiffness of the thin-wall panel made with 1/8" hardboard laminated to 1/2" gypsum board proved so successful that we also tested to see if the gypsum board could be reduced to 3/8" and the hardboard changed from tempered to untempered. Hence, we had two thicknesses of double laminates and two thicknesses of thin-wall ranging in price from 16.6¢ to 20.7¢/sq. ft. and ranging in weight from 2.5# to 4.5#/sq. ft. All four panels appeared to be so well qualified that they were scheduled for triple specimen tests.

(c) - Stud Wall Panels

Six different kinds of stud walls were built and tested. Two of these

panels had the studs turned flat (2" partition) and four of them had the studs turned crossways (4" partition). They were finished with gypsum board, fiber board, and plywood. After exploratory tests on these panels, it was decided that the strength and stiffness of the 2" and 4" stud walls finished with 3/8" gypsum board and 1/2" fiber board would provide the best criteria for evaluating the new studless walls. Hence, these four stud walls were selected for triple specimen tests.

2 - Evaluation of Fully Tested Panels

(a) Evaluation Under HHFA 1947 Performance Standards

Todays overwhelming need for an increased volume of housing at lower costs has accentuated the importance of developing new materials and construction techniques. However, there is no uniform basis for evaluation of these developments. In order to stimulate wide spread adoption of uniform performance standards by which the merits of new materials and building techniques can be judged and accepted, the HHFA published a Performance Standard in June 1947.* These standards are tentative and at the present time they are being investigated for revision. Our first analysis checked the strength and stiffness of all eight fully tested panels to determine if they would qualify under these standards.

This code limits the deflection or indentation under the 40# concentrated load to 1/120th. of the span between ribs plus 1/10", and allows 1/32" set. The stud panels finished with fiber board were the only ones that exceeded these limits. The HHFA standards also require that the panels sustain a 90#

*Performance Standards - Structural and Insulation Requirements for Houses - Housing Home and Finance Agency, June 1947.

concentrated load without cracking, breaking, or permanent buckling. All of the studless wall panels sustained the load but one out of three of the stud wall specimen finished with gypsum board failed. Hence, the 4 studless panels were qualified under this test, whereas all of the stud panels were disqualified, see Figure 5-1.

The HHFA Code does not require the panels to sustain the 60# sand bag impact loads without cracking or breaking at the principle structural elements. Instead it limits the residual deflection. No residual deflection is allowed under the 1' 6" drop. All of the panels were deformed between .022" to a .294". The Code specifies that the residual deflection under the 3' drop of the 60# sand bag shall not exceed 25% of the maximum deflection. The two laminated gypsum board panels were the only ones that exceeded this set limit. Therefore, all 8 types of panels were disqualified under the 1' 6" impact and the laminated gypsum board panels were also disqualified under the 3' impact, see Figure 5-2.

The uniform load of 15# per square foot deflected all eight types of panels more than the allowable 1/240th. of the span. However, there was no indication that this deflection was serious since no damage resulted under subsequent load up to 33-3/4#/ sq. ft. The residual deflection of double gypsum board panels made of 3/8" gypsum board exceeded the 25% limit. Hence, all 6 panels tested with the uniform load were disqualified under the HHFA Performance Standard requirements under this load, see Figure 5-3.

Thus, we found that the four different stud wall panels all failed under one or more criteria for each of the three different types of loads. The studless panels all qualified under the concentrated load but were dis-

FIGURE 5-1

PERFORMANCE VERSUS HHFA 1947 PERFORMANCE STANDARDS

TRIPLE SPECIMEN TESTS

CONCENTRATED LOAD AT WEAKEST POINT OF ELEMENT COVER

Panel Description	Avg. Set	Test Result	Avg. Indentation	Reason Panel Fails to Qualify, If Any
40 Pounds on 1" disc				
STUD PANELS				
4" thick - 3/8" gypsum board (AX)	.0106"		.050"	
4" thick - 1/2" fiber board (BX)	.0530"		.341"	Excessive Deflection
2" thick - 3/8" gypsum board (AY)	.0223"		.105"	
2" thick - 1/2" fiber board (BY)	.0403"		.290"	Excessive Deflec. & Set
STUDLESS WALLS				
1" double laminate (F)	.0033"		.052"	
3/4" double laminate (FCA)	.0066"		.102"	
5/8" thin-wall (OAA)	.0056"		.077"	
1/2" thin-wall (OI)	.0076"		.103"	
90 Pounds on 1" disc				
STUD PANELS				
4" thick - 3/8" gypsum board (AX)		failed		1 out of 3 panels failed
4" thick - 1/2" fiber board (BX)	.1926"		.726"	Excessive set
2" thick - 3/8" gypsum board (AY)		failed		1 out of 3 panels failed
2" thick - 1/2" fiber board (BY)	.1536"		.656	
STUDLESS WALLS				
1" double laminate (F)	.0163"		.118"	
3/4" double laminate (FCA)	.0250"		.245"	
5/8" thin-wall (OAA)	.0116"		.168"	
1/2" thin-wall (OI)	.0206"		.249	

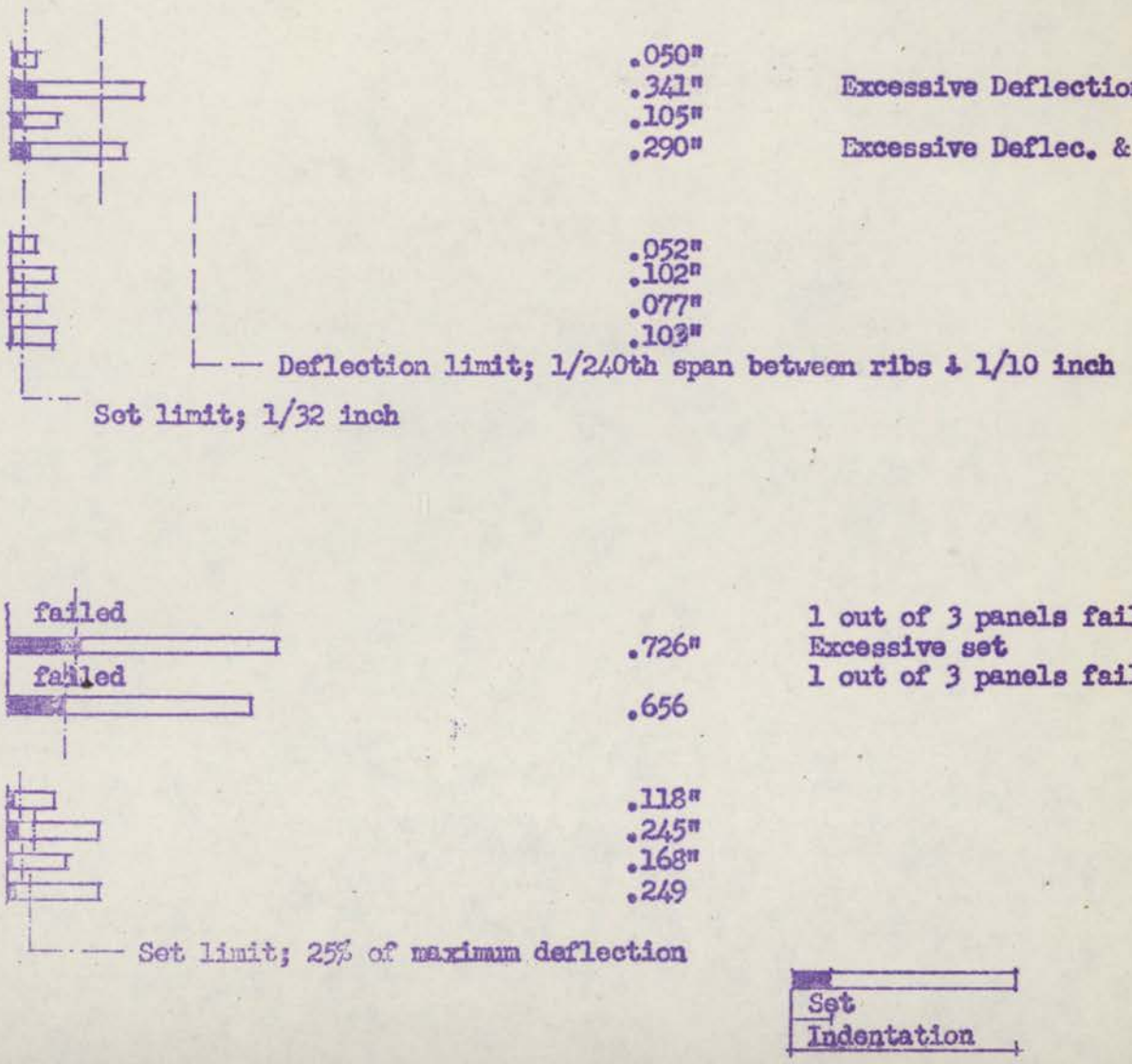
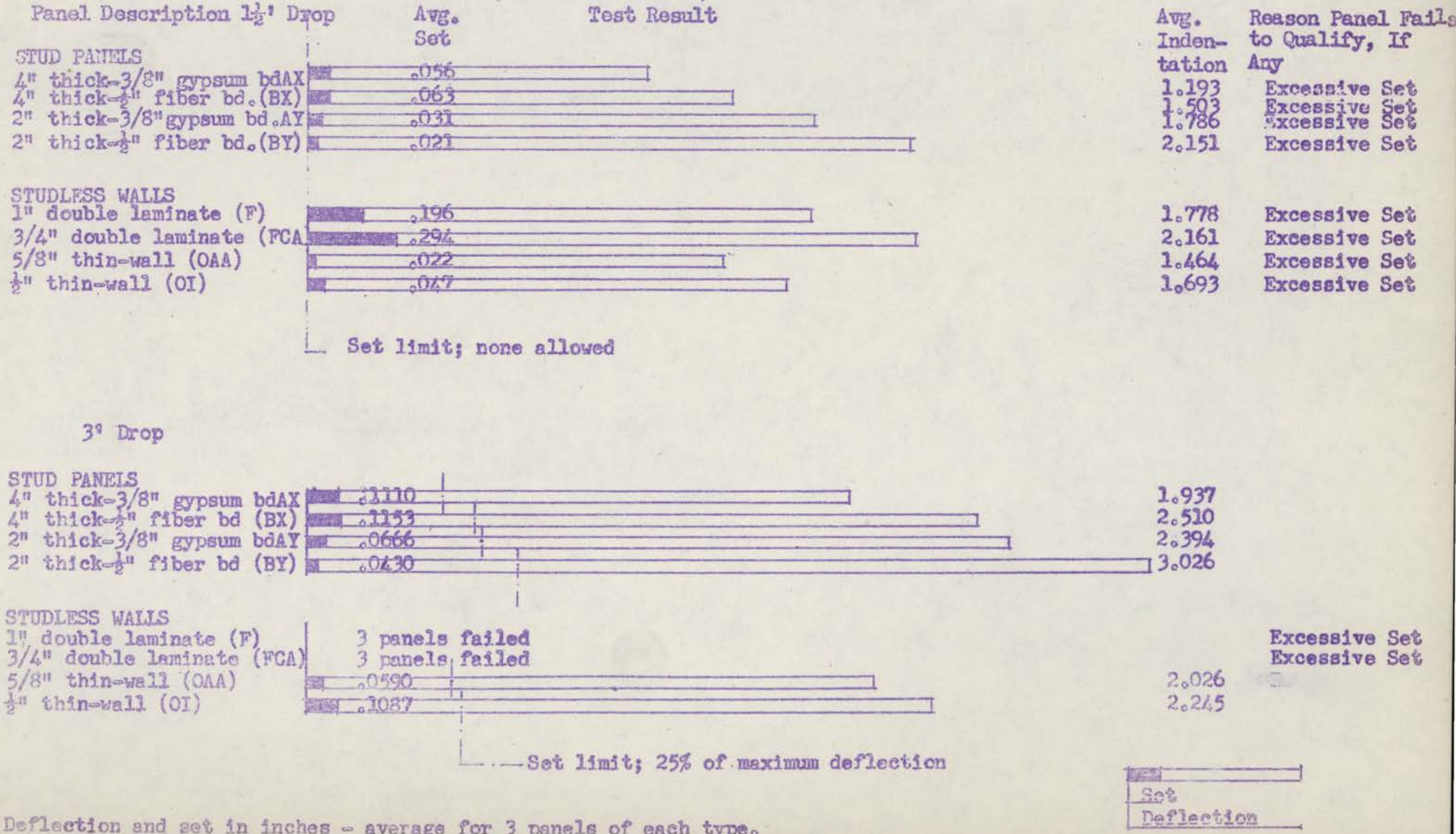


FIGURE 5-2

PERFORMANCE VERSUS HHFA 1947 PERFORMANCE STANDARDS
TRIPLE SPECIMEN TESTS
IMPACT AT THE WEAKEST POINT OF THE ELEMENT
(Not Element Cover) WITH 60# SAND BAG



Deflection and set in inches - average for 3 panels of each type.

FIGURE 5-3

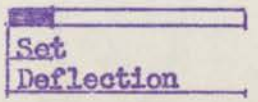
PERFORMANCE VERSUS HHFA 1947 PERFORMANCE STANDARDS
TRIPLE SPECIMEN TESTS
UNIFORM LOAD

Panel Description	Avg. Set	Test Result	Avg. Indentation	Reason Panels Fails to Qualify, If Any
15#/sf Applied Load				
STUD PANELS				
4" thick - 3/8" gypsum board (AX)		not tested		
4" thick - 1/2" fiber board (BX		not tested		
2" thick - 3/8" gypsum board (AY)	a		.5260	Excessive Deflec.
2" thick - 1/2" fiber board (BY)	a		.7190	Excessive Deflec.
STUDLESS WALLS				
1" double laminate (F)	a		.3150	Excessive Deflec.
3/4" double laminate (FCA)	a		.3640	Excessive Deflec.
5/8" thin-wall (OAA)	a		.3280	Excessive Deflec.
1/2" thin-wall (OI)	a		.4790	Excessive Deflec.

Deflection limit 1/240th. of the span

33-3/4#/sf Applied Load				
STUD PANELS				
4" thick - 3/8" gypsum board (AX)		not tested		
4" thick - 1/2" fiber board (BX)		not tested		
2" thick - 3/8" gypsum board (AY)	.0790		1.382	
2" thick - 1/2" fiber board (BY)	.0953		1.703	
STUDLESS WALLS				
1" double laminates (F)	.1163		.5910	
3/4" double laminates (FCA)	.3090		1.070	Excessive Set
5/8" thin-wall (OAA)	.0936		.7340	
1/2" thin-wall (OI)	.1806		.9740	

Set limit; 25% of maximum deflection



a -- No reading.

qualified under the impact and uniform load tests. On the basis of this analysis, it was concluded that the NHFA 1947 Performance Standards are not suitable for the evaluation of non-bearing partitions.

(b) - Strength versus Stud Panel Performance

The second analysis compared the strength of the studless panels under all four tests with the strength of the four different types of conventional nonload-bearing stud walls which were given triple specimen tests. In accordance with BMS 109,* the strength is assumed to be directly proportional to the least load causing damage, hence the least load causing damage is the measure of strength.

The 90# concentrated load punctured 1 out of 3 specimens of both the 2" and 4" stud wall panels finished with gypsum board. None of the studless walls were damaged in any way. This demonstrated that the strength for all four types of studless panels was greater than for the stud panels finished with 3/8" gypsum board.

Impact from drops up to 3' by the 60# sand bag over the studs caused no failure of the studs or the covering on the fiber board stud panels; however, the unloaded face, of a 2" and a 4" stud wall panel finished with gypsum board split due to the bending caused by a 2' drop of the 60# sand bag. When the sand bag was dropped between the studs, both the fiber board and the gypsum board stud panels were damaged by the 15# sand bag under drops with 66% to 75% less momentum than was required to damage the gypsum board panels with impact over the stud, see Figure 3-4.

*Criteria B, page 83 - National Bureau of Standards BMS 109 "Strength of Houses - Application of Engineering Principles to Structural Design".

FIGURE 5-4
HEIGHT OF DROP AND MOMENTUM FOR
LEAST IMPACT CAUSING DAMAGE TO ELEMENT COVER
TRIPLE SPECIMEN TESTS

Panel Description	Sand Bag Between Ribs			Sand Bag Over Ribs	
	HT. of Drop		Momentum	HT. of Drop	Momentum
	15 lbs. Sand Bag	60 lbs. Sand Bag		60 lbs. Sand Bag	
STUD PANELS					
4" thick - 3/8" gypsum board (AX)	1½ ft	(c)	4.6 lbs. Sec.	2 ft. (d)	21.2 lbs. Sec.
4" thick - ½" fiber board (BX)	2 ft	(c)	5.3 lbs. Sec.		
2" thick - 3/8" gypsum board (AY)	2 ft (a)	(c)	5.3 lbs. Sec.	2 ft. (d)	21.2 lbs. Sec.
2" thick - ½" fiber board (BY)	3½ ft (a)	(c)	7.0 lbs. Sec.		
STUDLESS PANELS					
1" double laminate (F)		1 ft	15.0 lbs. Sec.	no test	
3/4" double laminate (FCA)		1 ft	15.0 lbs. Sec.	no test	
5/8" thin-wall (OAA)		2½ ft	23.7 lbs. Sec.	no test	
½" thin-wall (OI)		3 ft (b)	25.9 lbs. Sec.	no test	

(a) Two specimen tested.
(b) First signs of damage from 60 lbs. swinging sand bag from panel in working model - 1' - 3" drop.
(c) Damaged with lighter bag.
(d) Unloaded face was damaged. Damage due to tipping of sand bag not considered in this tabulation.

Comparison with the performance of the studless panels shows that the gypsum board laminated panels can withstand more than twice the impact that damaged the strongest of the stud panels when loaded between studs, and the thin-wall panels (gypsum board laminated to hardboard) can withstand three times that amount. Furthermore, the thin-wall panel withstood impact with 10% more momentum than the stud panels finished with gypsum board when they were loaded over the stud.

Thus we see that the impact resistance over the rib on the stud panels is greater than that of the laminated gypsum board panels but not as great as that of the thin-wall panels. Such strong ribs are needed for partitions, which support the ceiling or other structural elements, in order to protect life and limb in event of severe impact loads on the ribs. Such a load, however is more severe than normal occupancy loads and is very unlikely to occur. It therefore, should not be necessary to design nonload-bearing partitions to withstand greater impact loads than will damage the finish material of currently acceptable stud partitions.

If we consider this as a basis for comparison, all four types of studless panels qualified as stronger than stud panels. If, on the other hand we use the impact resistance of the stud panels when loaded over the stud as the criteria, we find that the thin-wall panels qualify but the laminated gypsum board panels do not.

Two variations of the standard impact test helped to confirm the strength of the thin-wall panels. The first was impact drops on the closet or hardboard side of the test panels. Four out of the 6 thin-wall panels were so tested. These tests showed that 18" drops on the hardboard side of the thin-

wall panels caused the nails to pull loose, but none of the three specimens so tested were damaged until the 2' 6" drop, thus proving that the thin-wall panel is as strong on the closet side as it was on the exposed (gypsum board) side but the nailed connection did not develop the full strength of the panel.

The second was swinging sand bag impact tests on the working model, Appendix page 96 to 109.

The taped edges of the thin-wall panels on the working model were held more securely than the edges of the test panels which were nailed only. As a result, less impact was required to cause damage to the 1/2" thin-wall panels that were installed in the working model. Even so, they withstood the 12" impact by the swinging sand bag which was more than twice the impact that damaged the strongest of the wallboards on the stud panels when loaded between the studs. Hence, the thin-wall panels on the working models were stronger than either type of wallboard on the stud panels when loaded between the studs.

IMPACT REQUIRED TO DAMAGE
THIN-WALL PANEL IN WORKING MODEL TESTS

Closet	Compartment	Test No.	First Drop Causing			
			Damage		Failure	
			Height of Drop	Deflection	Height of Drop	Deflection
#1	#2	#2	24"	1.637"	36"	1.875"
#1	#1	#3	24"	1.641"	30"	1.891"
#2	#1	#1	15"	1.266"	a	a
#2	#3	#3	15"	1.188"	36"	1.860"
#2	#2	#3	24"	1.563"	b	b

None of the panels were damaged by the uniform loads ranging from 33#/sq.ft. to 38#/sq. ft. and it is therefore not possible to show that one panel was stronger than any other under uniform load.

(c) Building Code Requirements

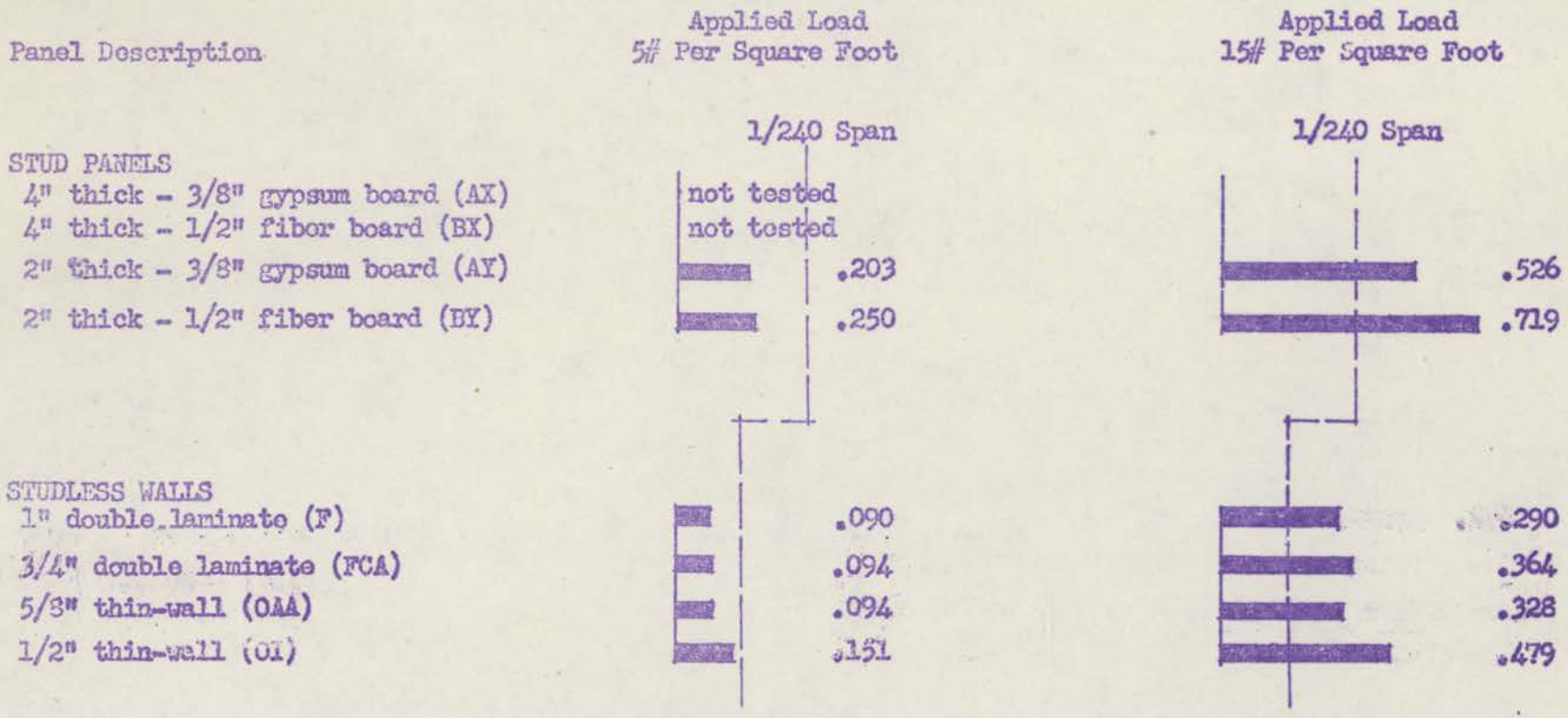
The third analysis was made to determine whether the panels were strong enough to sustain the uniform loads specified under various building codes. The Basic Building Code* specifies that interior walls and partition surfaces in habitable space shall be finished with materials which are of adequate strength to resist a horizontal force of not less than 5#/sq.ft. The HHFA 1947 Performance Standards specifies that nonload-bearing partitions shall not deflect more than 1/240th. of the span under a uniform load of 15#/sq. ft. and shall sustain 33-3/4#/sq. ft. without failure. Most Building Codes do not specify strength or stiffness requirements for nonload-bearing partitions, but those that do usually specify uniform load resistance within the range of these two requirements.

The 2" stud panels as well as the studless panels all defelcted less than 1/240th. of the span under the 5#/sq. ft. load, but they all deflected more than 1/240th. of the span under the 15#/sq. ft. load, see Figure 5-5. This deflection limit has been established for the purpose of preventing cracking of wall covering materials under live loads. However, this requirement should not be necessary if the construction is subjected to tests which prove that the panel can sustain at least two times design load without cracking of the finish material. On this basis all of the studless panels as well as the 2" stud panels are adequate for a 15#/sq. ft. uniform load because they all sustained 33 to 38#/sq. ft. without any signs of damage

*Basic Building Code - Building Officials Conference of America - 1950 edition - Article 855.9.

FIGURE 5-5

AVERAGE DEFLECTION* UNDER UNIFORM LOAD
TRIPLE SPECIMEN TESTS



* Average deflection in inches.

or failure.

(d) Stiffness versus Conventional Panel Performance

The fourth analysis considered stiffness as an esthetic quality. Smooth walls built of relatively rigid finish materials have long been a standard in this country and because of this tradition, flexible wall finish materials are generally considered to be flimsy and un-acceptable in the eyes of the average home purchaser. In order to be sure of public acceptance it was decided that the new panels should be as stiff as the weakest part of a conventional 2" stud wall.

Figure 5-6, 5-7 and 5-9 show that the studless panels deflected no more than the stud panels under the concentrated load, uniform load, and impact at the weakest point of the element cover.

Figure 5-8 shows that even when compared with the stiffness of stud walls subjected to impact over the stud, the new panels are all stiffer than the 2" stud wall finished with fiber board under impact up to a 2' drop of the 60# sand bag. Furthermore the thin-wall panels are stiffer than both types of 2" stud walls. Although the panels are not as stiff as the 4" stud walls, the difference is relatively small and it is very doubtful that it would be visibily apparent. This comparison was made merely because the standard test procedure specifies that the sand bag shall be dropped over the stud on stud walls, but it probably is not necessary to design nonload-bearing partitions to resist impact loads any more than the weakest part of currently acceptable stud wall construction. It was for this reason that the stud wall panels were subjected to the newly developed 15# impact test. As stated above, all of the studless panels qualified on this basis.

FIGURE 5-6

COMPARATIVE STIFFNESS UNDER CONCENTRATED LOADS
AT WEAKEST POINT OF ELEMENT COVER
TRIPLE SPECIMEN TESTS

	Avg. Indentation 40 POUNDS	Avg. Indentation 90 Pounds
STUD PANELS		
4" thick - 3/8" gypsum board (AX)	.050"	1 out of 3 failed
4" thick - 1/2" fiber board (BX)	.341"	.726"
2" thick - 3/8" gypsum board (AY)	.105"	1 out of 3 failed
2" thick - 1/2" fiber board (BY)	.290"	.656"
STUDLESS WALLS		
1" double laminate (F)	.052"	.118"
3/4" double laminate (FCA)	.102"	.245"
5/8" thin-wall (OAA)	.077"	.168"
1/2" thin-wall (OI)	.103"	.249"

Average deflection and indentation.

NOTE: Performance curve can not be drawn since only 2 loads were applied.

FIGURE 5-7
COMPARATIVE STIFFNESS UNDER UNIFORM LOAD
TRIPLE SPECIMEN TESTS

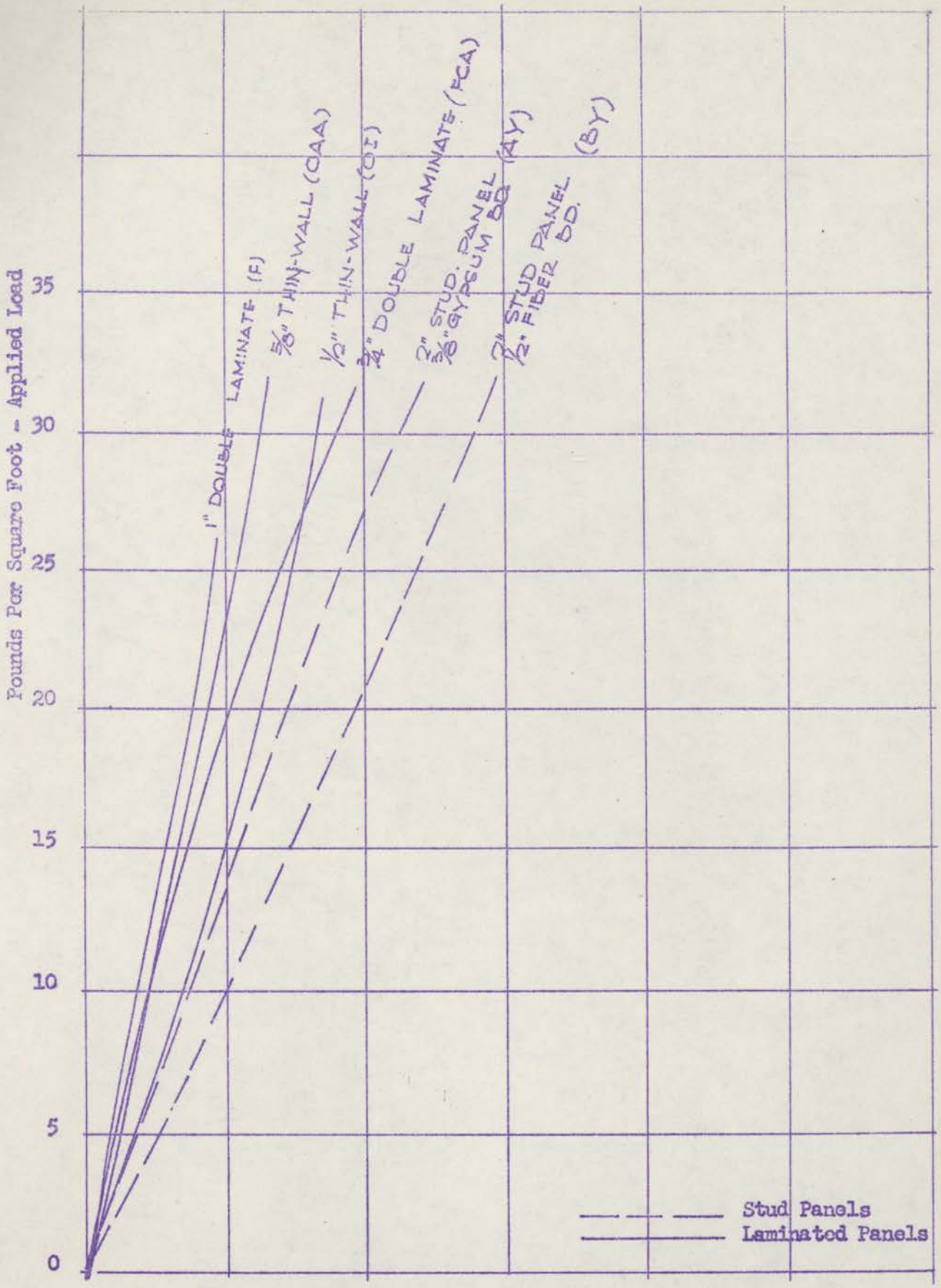
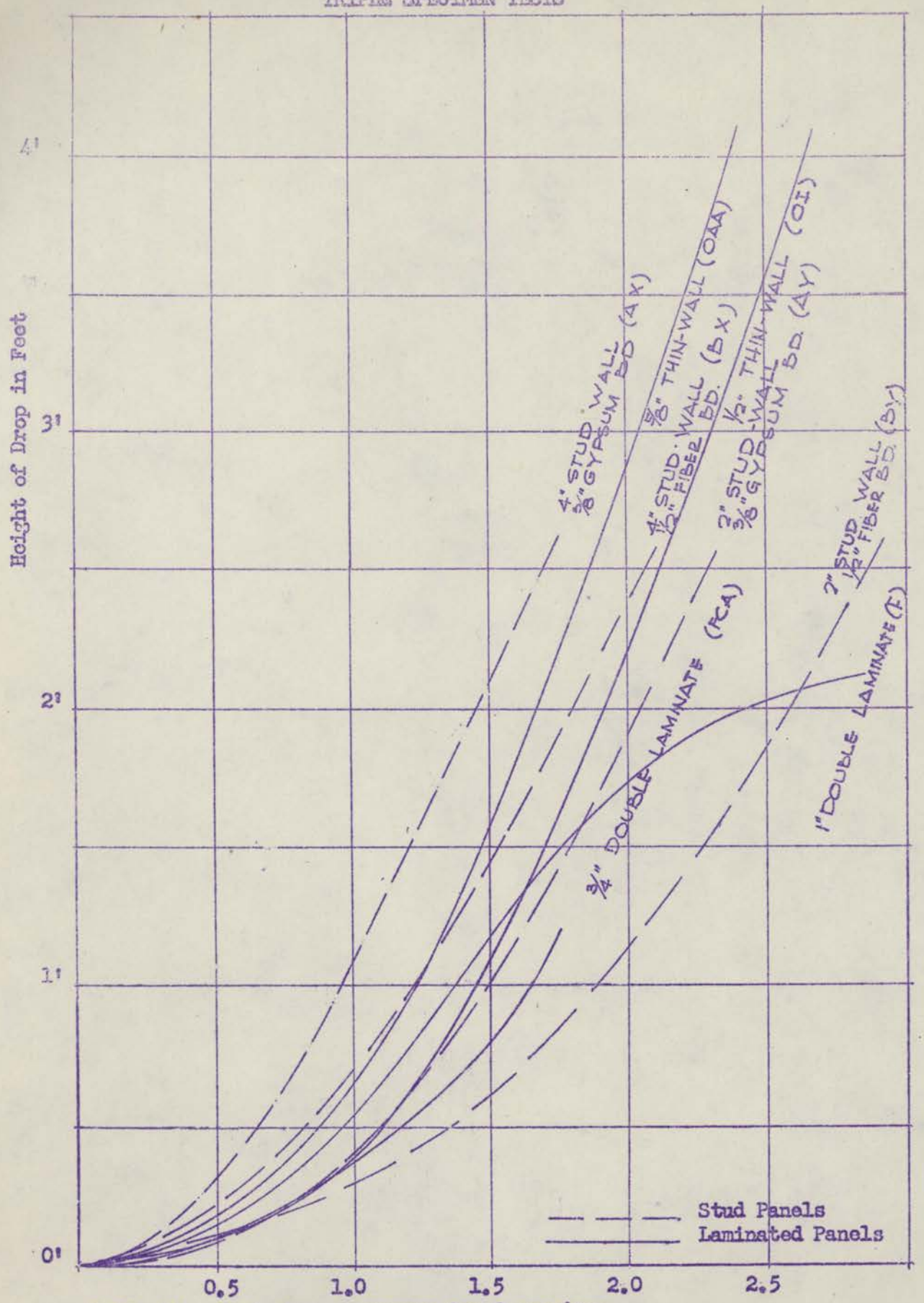


FIGURE 5-8

COMPARATIVE STIFFNESS UNDER IMPACT AT WEAKEST POINT OF ELEMENT - (Not element cover)

60# SAND BAG WITH DROPS AT 6" INCREMENTS UP TO 4'-6"

TRIPLE SPECIMEN TESTS

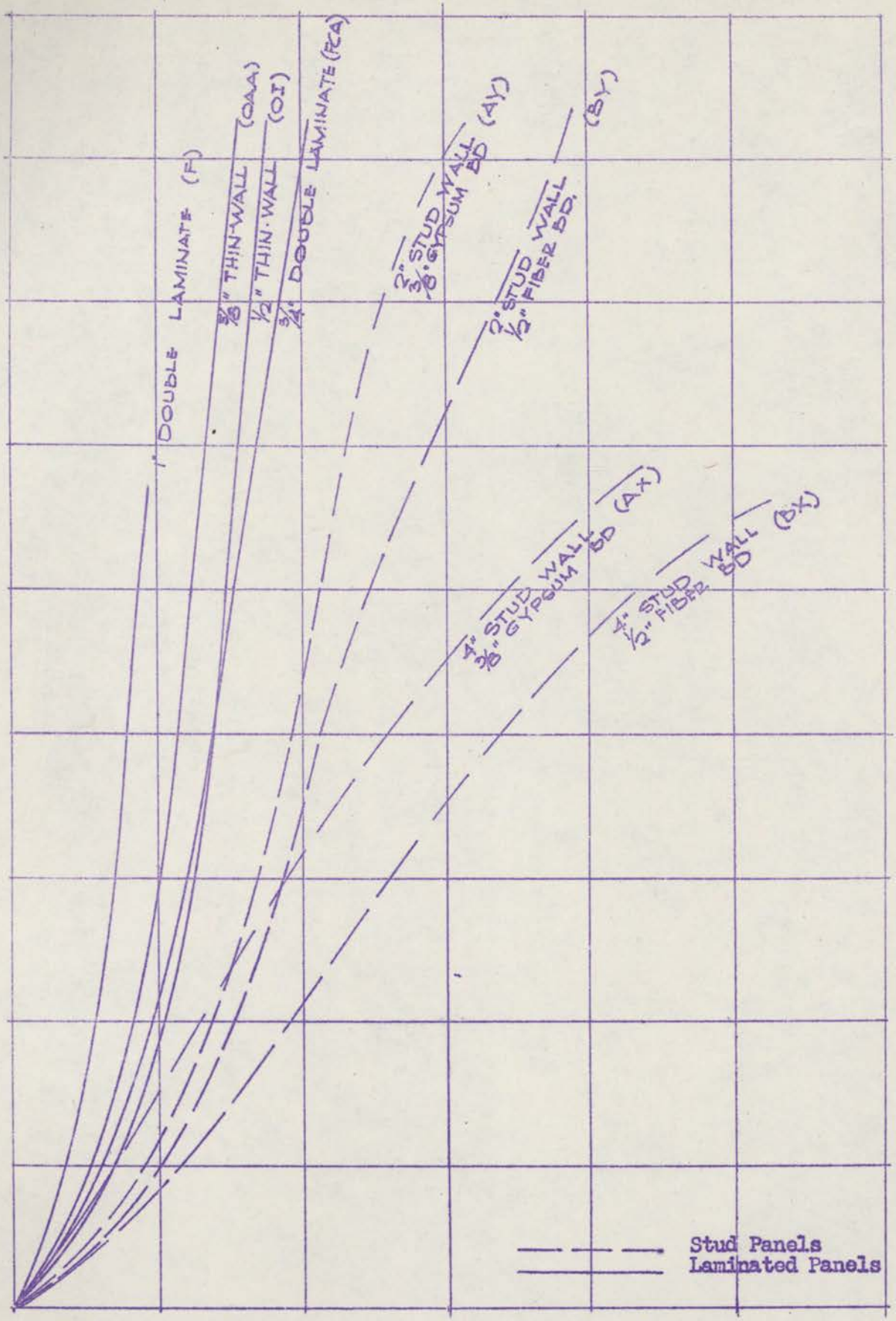


Deflection in inches - average for 3 specimen

F & FCA average readings not available for higher drops because one or two specimen failed. AY tests discontinued with 3'-0" drop.

FIGURE 5-9

COMPARATIVE STIFFNESS UNDER IMPACT AT WEAKEST POINT OF ELEMENT COVER
15# Sandbag with drops at 6" increments up to 4'-6"
Triple Specimen Tests



Deflection in inches - Average for 3 specimen of each type.

AY - only 2 panels tested.

Some authorities feel that non-bearing partitions should be designed to withstand only occupancy loads. The concentrated and impact loads are generally considered to be the only occupancy loads. There is no general agreement as to the proper design load for these two occupancy loads. The HHFA Performance Standards have established the 1-1/2' drop of the 60# sand bag and the 40# concentrated load as design loads. On the basis of these two loads, the thin-wall panels are stiffer than either type of 2" stud wall panels under the standard test procedure.

(e) Three Types Of Studless Panels Prove Acceptable

All four of the fully tested studless panels have proven to be stronger and stiffer than the weakest part of the 2" stud wall panels and the thin-wall panels equal or exceed the strength and stiffness of the ribbed elements of the 2" stud panels. We therefore, find that all four of the new panels are adequate for use on the back wall of a closet 4' wide provided the panels are fastened around the edge and at the shelf 6' above the floor.

The set of the 4 x 8 panel must be considered when evaluating job ease. The saving in material cost is also an important evaluation factor. The following table gives comparable data:

	Cost Saving Compared to Stud Wall with 3/8" Gypsum Board	Wt. per 32 sf. Panel
3/4" laminate; 2 pcs. of 3/8" gypsum bd. (FCA)	44%	100#
1" laminate; 2 pcs. of 1/2" gypsum bd. (F)	37%	144#
1/2" thin-wall; 3/8" gypsum bd & 1/8" tempered hardboard (OI)	33%	75#

	Cost Saving Compared to Stud Wall with 3/8" Gypsum Board	Wt. per 32 sf. Panel
5/8" thin-wall; 1/2" gypsum bd and 1/8" tempered hardboard (OAA)	21%	97#

Experience in working with the 4 x 8 laminated panels showed that 100# is the maximum weight that can be easily handled by one or two men, hence the laminated 1/2" gypsum board panel was ruled out from final consideration.

The selection from the three remaining types of panel is left to the option of the designer and builder. However, the extra strength in the thin-wall panels will reduce the possibility of damage during construction, and the difference in the strength between the less expensive 1/2" thin-wall and the 5/8" thin-wall does not appear to be important. We have accordingly recommended the 1/2" thin-wall panel made from 3/8" gypsum board and 1/8" untempered hardboard in the working drawings for closet walls.

B - Evaluation of 2 x 8 Divider Panels

A companion member which is essential in order to utilize a studless back wall panel for closets is the divider panel that separates adjoining closets. This panel must be 8' high and approximately 2' wide. The economical back wall will be far more valuable if this element can also be built lighter, thinner and less expensive than stud wall construction. Previous projects of the Small Homes Council developed a prototype* which proved well suited for this purpose. This panel was made with 2 x 8 sheets of plywood nailed into a grooved 1-3/8" x 3-1/4" frame. In order to save money and utilize the same materials already required for construction of the thin-wall panel, 1/8" hardboard was used for the 2 x 8 panel and the

*Staff Housing Project Built in Urbana 1949.

rabbeted frame as made of 2 x 2's, Appendix page 94. The other divider panel on the first closet was designed to further minimize the labor of fabrication. Instead of surrounding the 2 x 8 hardboard panel with a rabbeted member, the front and back edge was stiffened with a pair of 1 x 2's, Appendix page 95.

In order to test the divider panels as well, as the thin-wall panels, two working models were built. Working model No. 1 was finished with two more divider panels modified to improve the weakness of the first two panels. These four panels were subjected to swinging sand bag tests. Divider No. 1 withstood impacts up to 3' by the 60# swinging sand bag directly on the front edge and on the thin-wall panels fastened to the back edge (see test No. 1). None of these impacts caused damage or excessive deflection. The resistance to these loads proved that the divider panel could not be damaged or pulled loose by impact directly on the front or back of the divider panel with impact swings up to 18".

The unsupported front edge of the divider panel proved to be the weakest part when subjected to impact from the side. Hence, all 4 divider panels were given this test, see Appendix page 96 to 109. The first 2 panels deflected more than the 2" stud wall finished with 3/8" gypsum board, see Figure 5-10, and were therefore classified as too flimsy. This conclusion was confirmed by observations during the test that the panels could be easily deflected by a light push of the hand. Therefore, the next two divider panels were built with stiffer front frame members. A 2" x 4" was used for the front frame member on panel No. 4. This panel proved much stiffer but it started to break loose at the bottom under an 18" impact.

Panel No. 3 was built the same as panel No. 1 with the front frame

FIGURE 6-10

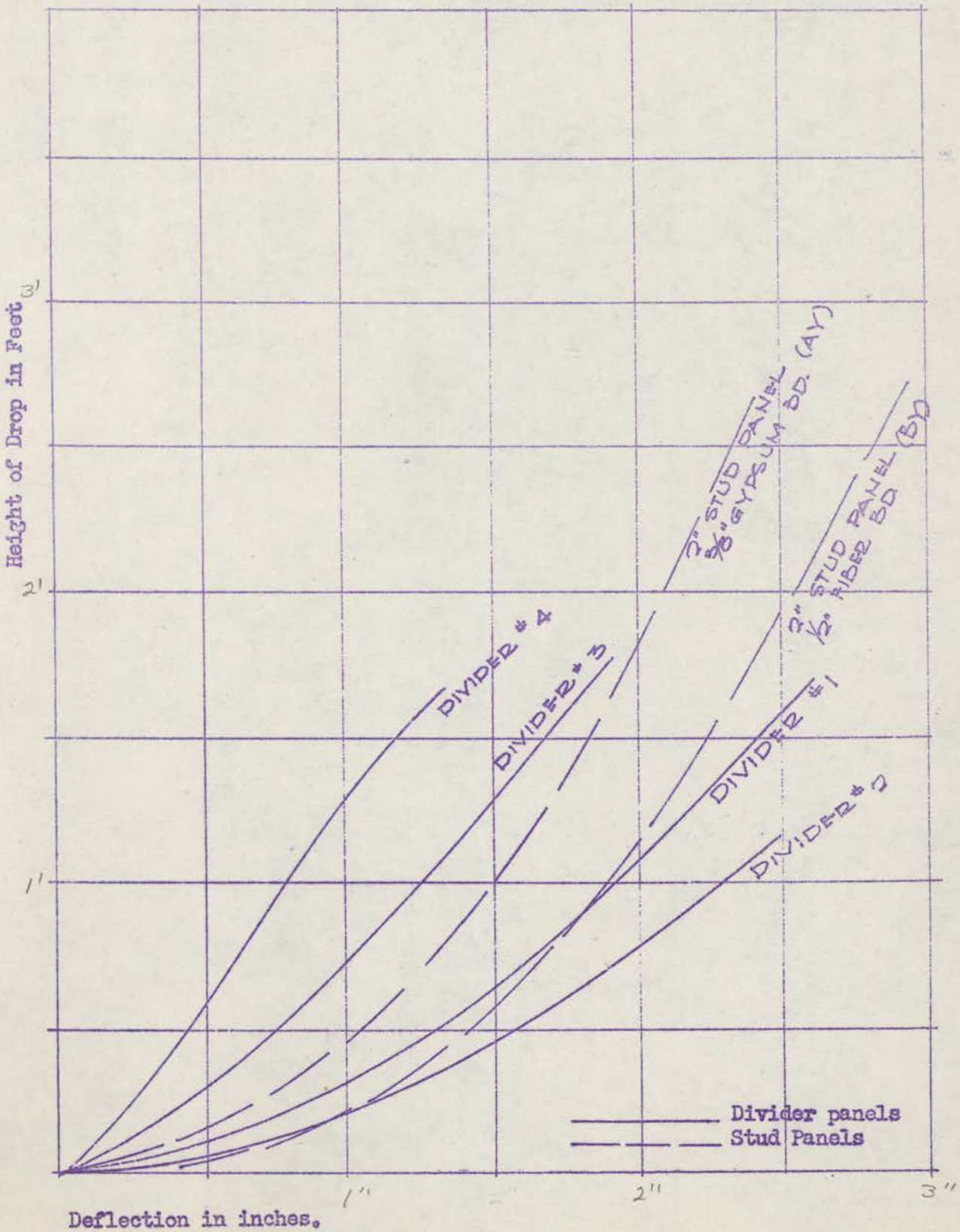
COMPARATIVE STIFFNESS UNDER IMPACT

SWINGING 60# SAND BAG

Front edge of divider panels working model closets #1 and #2 - single specimen.

vs.

Mid-span on 2" stud wall panels - Sand bag dropped over stud - Three specimen average.



member trimmed with three pieces of 1/2" white pine. This trim served two important functions;

First, it stiffened the panel sufficiently to reduce the deflection 33% by comparison with panel No. 1, see Figure 5-10. Thus this panel was stiffer than the 2" stud walls even under impact on the stud.

Second, it strengthened the connection of the front post at the floor and ceiling with the result that this panel was not damaged until the 24" impact, whereas the others were damaged with drops from 6" to 18".

Comparative Strength of Divider Panels on Working Models
Under 60# Swinging Sandbag Impact Tests

Closet No.	Divider No.	Test No.	First Drop Causing			
			Damage		Failure	
			Height of Drop	Symptom	Height of Drop	Symptom
1	1	4	17"	1/8" set at point of impact	24"	Cracked 2x2 bottom frame member & hardboard
1	2	5	6"	1/8" set at point of impact	-	Tests discontinued with 14" drop
2	3	4	24"	Front trim member cracked	-	Tests discontinued with 24" drop
2	4	5	18"	1/8" set at bottom of panel	21"	Cracked 2 x 2" bottom frame member & hardboard

Panel No. 3 was accordingly selected as the best panel because it could sustain the greatest impact without damage and it was stiffer than the ribbed portion of stud wall panels finished with 3/8" gypsum board or 1/2" fiber board. The material for this panel costs 40% less than the same sized stud wall finished with 3/8" gypsum board.

C - Additional Elements

In order to further broaden the use of this new type of closet construction three more elements were developed.

1 - Multiple Shelf Unit

Many items to be stored within closet space can best be accommodated in a series of shelves one on top of the other. The width of the shelves varies according to the space requirements but most requirements can be met with shelf units 16", 24", or 32" wide. The depth needed for storage of this type is generally 16". The height of the shelf space ranges from 3" to 24".

In order to meet this need, a multiple shelf unit was designed. This unit consists of a series of fixed shelves 24" o.c. supported by side panels.* Adjustable shelves may be installed in accordance with the space needs and budget.

Before developing this multiple shelf unit, it was only practical to design closets in increments of 2 feet. When this unit is used as a structural member to support thin-wall panels, the closets can be designed for any width.

2 - Framed End Wall Panel

Some closets require a free standing wall on one end. The framed

*See working drawings entitled "Closet Wall Construction-With Thin-Wall Panels Developed During A Research Investigation Conducted by the Small Homes Council, University of Illinois.

divider panel is not esthetically acceptable for this use. This panel was accordingly revised to use a 2' x 8' thin-wall panel set into a recess in the face of the frame in such a manner as to provide a smooth surface*

3 - Closet Fronts

The design and development of new closet fronts are not in the scope of this project. Our analysis showed that many of the manufactured closet fronts which are commercially available provide full access and are less expensive than the conventional door in a stud wall. In view of the improved quality and functional advantages of these manufactured units, the thin-wall closet construction has been designed to provide the necessary jamb and head connections for the popular folding doors and sliding doors. Other types of doors such as the shelf-on-door would require modification of the divider panel design. These and other modifications can be easily developed on the basis of data in this report and the working drawings of "Closet Wall Construction".

D - Evaluation of Thin-Wall Closet

As we have seen earlier, the material for a 4' x 8' thin-wall panel 1/2" thick saves 33% and a 2' x 8' framed divider panel saves 40% as compared to the material for equally sized stud walls finished with 3/8" gypsum wall board. In order to fully evaluate the possible savings as compared to the conventional stud wall closet, it is necessary to compare the complete cost including the labor.

A closet 12' wide with an 8' section facing one way and a 4' section facing the opposite way was selected for this cost analysis. Comparing the cost in percentage, using the stud wall closet as a base of reference, the

*See working drawings entitled "Closet Wall Construction - With Thin-Wall Panels Developed During A Research Investigation Conducted by the Small Homes Council, University of Illinois.

thin-wall closet is 15% less expensive than the conventional stud wall closet providing the shelf space for both closets is equal, see Figure 5-11. If a multiple shelf unit is substituted for the divider panel in the thin-wall closet, four times as much shelf space is provided and the thin-wall closet can be built for the same cost as the conventional stud wall closet.

The saving will be less if the closets are not designed to use full 4' x 8' thin-wall panels. Waste sheets larger than 2' wide can be cut down to give a reuseable 2' wide panel. Therefore, waste 1' 8" wide is the largest chargeable to a closet. Such waste on a 6' 4" wide closet would reduce the saving from 15% to 10%.

The cost for two of the manufactured full access closet fronts which are well suited for use with the thin-wall closet were also compared to the cost of the stud wall closet front. The saving depends upon the type of front that is selected. Folding doors can save up to 42% and sliding doors can save up to 32%, see Figure 5-12.

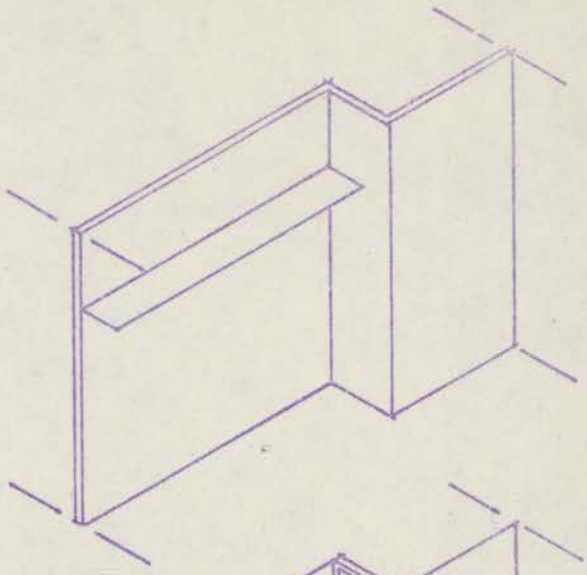
These cost savings of course, depend on the relative cost of the different building materials, and will vary from locality to locality and time to time. For instance, the material cost on which this analysis was made was such that 1 bd. ft. of 2" x 4" cost 81.5% of the cost for the material for 1 sq. ft. of thin-wall panel. If on the other hand, the board foot price of 2" x 4" were 50% less than the cost of 1 sq. ft. of thin-wall, the saving would have been one-half as much, and conversely if the board foot cost of 2" x 4" were 50% more than the material for 1 sq. ft. of thin-wall, the saving would have been more than doubled. Since it is likely that dimension lumber

FIGURE 5-11

COMPARATIVE COST IN PERCENTAGE USING COST OF STUD WALL CLOSET AS BASE OF REFERENCE

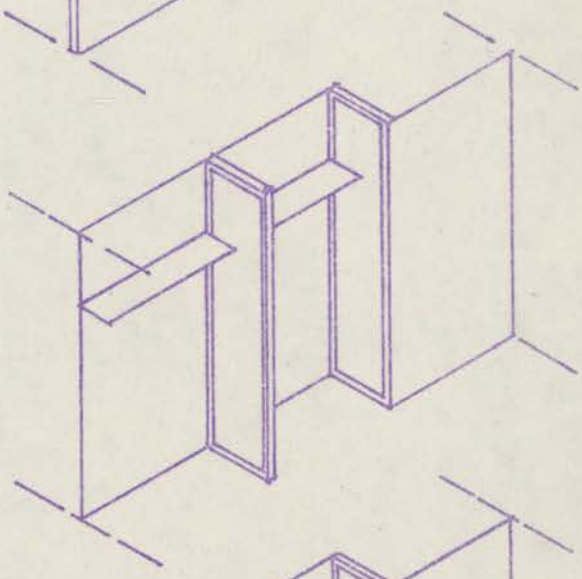
Stud wall with 12 sq. ft. of shelves.

100%



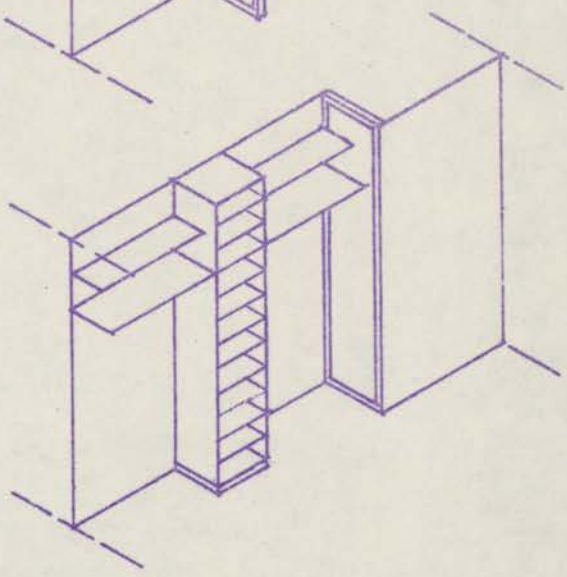
Thin-wall with 12 sq. ft. of shelves.

85%



Thin-wall with 49 sq. ft. of shelves.

100%



NOTE:

These costs are based on the time studies of the Small Homes Council, The Building Estimator's Reference Book by F. R. Walker and Dealer to Contractor material rates for projects under our supervision. The labor on the thin-wall closet is based on the time required to build working model No. 2. Further experience should reduce labor cost on this type of construction.

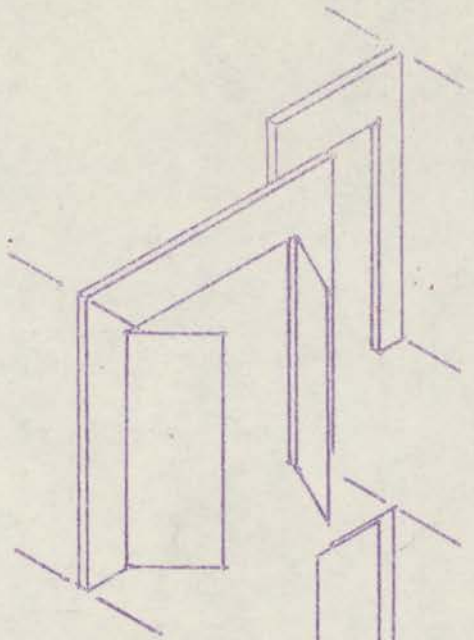
FIGURE 5-12

CLOSET FRONTS

COMPARATIVE COST IN PERCENTAGE USING TEST OF STUD WALL WITH HINGED DOOR AT BASE OF REFERENCE

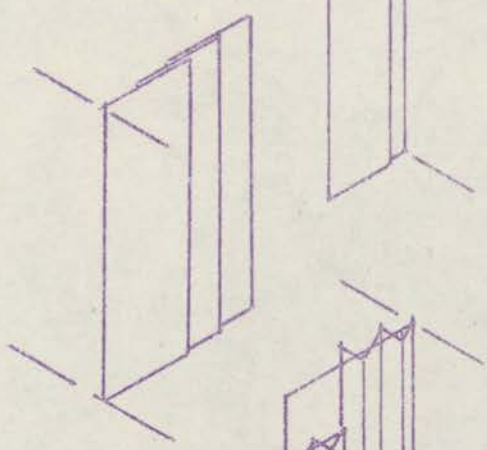
Stud wall fronts with 6'-8" x 2'-8" hinged door.

100 %



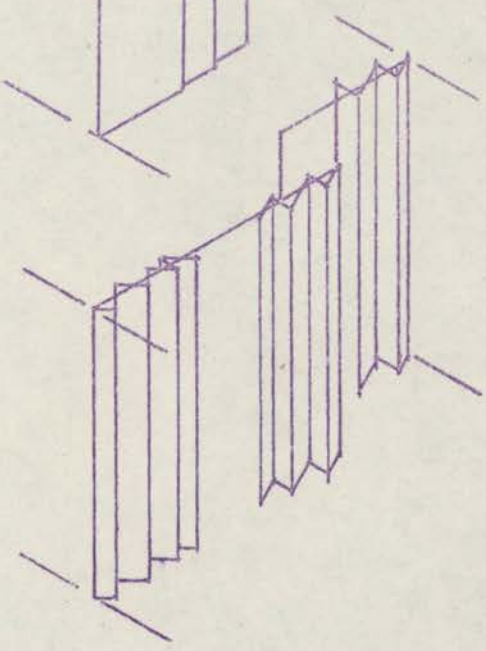
Full access fronts with metal edged hardboard sliding doors.

68%



Full access front with woven wood folding doors.

58%



NOTE:

These costs are based on the time studies of the Small Homes Council, The Building Estimator's Reference Book by F. R. Walker and Dealer to Contractor material rates for projects under our supervision.

will become more scarce in the future its price may increase faster than wallboard. If this is the case, the thin-wall closet will become even more economical as time passes.

E - Future Research

The thin-wall panel developed in this research program points the way towards the development of economical nonload-bearing partitions designed to utilize 20th. Century know-how and production methods. The growing use of clear span truss as well as post and beam construction has opened the way to use new types of non-bearing partitions to separate all rooms in the house.

This experiment points to laminated wall panels as one of the logical means of improving non-bearing partitions. Most of the laminated panels that have been developed to date are far too expensive for this purpose because they were designed for exposure to the weather and the loads of exterior walls or roofs. Recent work with triple laminated fiber board* and gypsum board** panels has shown the possibility of developing economical laminated non-bearing wall panels which are capable of spanning from floor to ceiling with cross wall bracing over 12' o.c. Further research should make it possible to build such panels thinner and lighter in weight, and at the same time improve their washability resistance to surface wear, sound resistance, and other performance characteristics.

* Johns-Manville, Utility Partition.
** United States Gypsum Company, 1-1/2" Laminated Sheet Rock Partition.

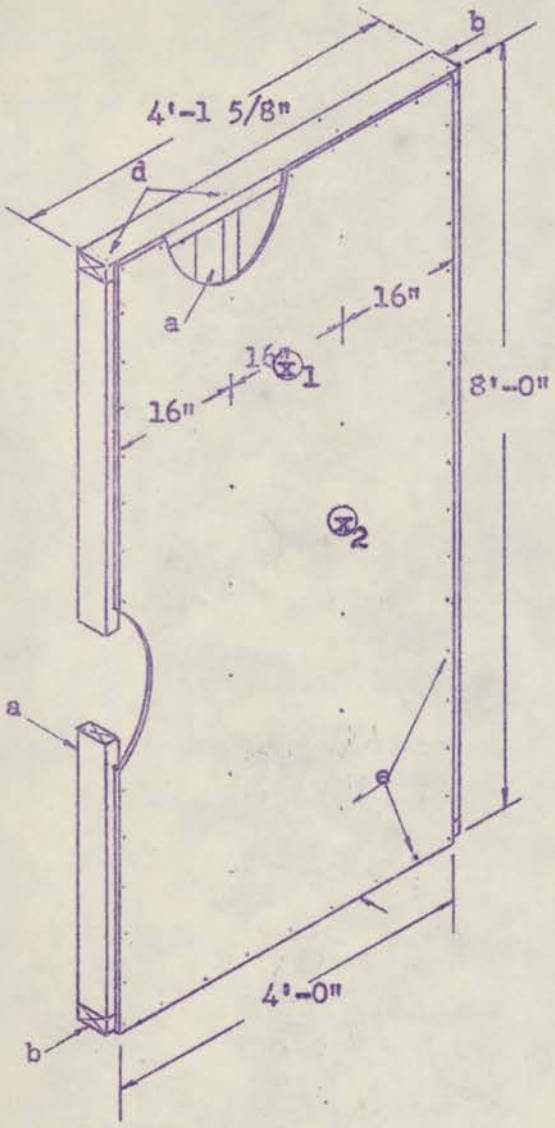
J. T. L.

A P P E N D I X

4" STUD WALL

1/4" fir plywood
2 sides studs, 16" oc

TEST PANEL CX
CLOSET WALL PROJECT
L.D.R.C.



a - 4 studs - 16" o. c.
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 1/4" Douglas Fir plypanel, grade-A-D 4/0 x 8/0 nailed on both sides of stud frame

d - 16d common nails through top and bottom plate - 2 per junction

e - 4d finish nails, bright, 6" o. c. along edges and 12" o. c. at intermediate studs. 3/8" minimum edge distance

Built: August 29, 1951

Mtls Cost/Sq.Ft.	53.3¢
Weight/Sq.Ft.	3.25#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.
x1 - Subscript denotes test number.

TABULATION OF TEST RESULTS PANEL CX

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.284	.013
90#	.485	.027

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.953	.087
1/0	1.266	.090
1/6	1.500	.068
2/0	1.719	.083
2/6	2.141	.128
3/0	2.391	.136
3/6	2.609	.170
4/0	3.172	.247

OBSERVATIONS OF DAMAGE ON PANEL CX*

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

60# IMPACT TEST

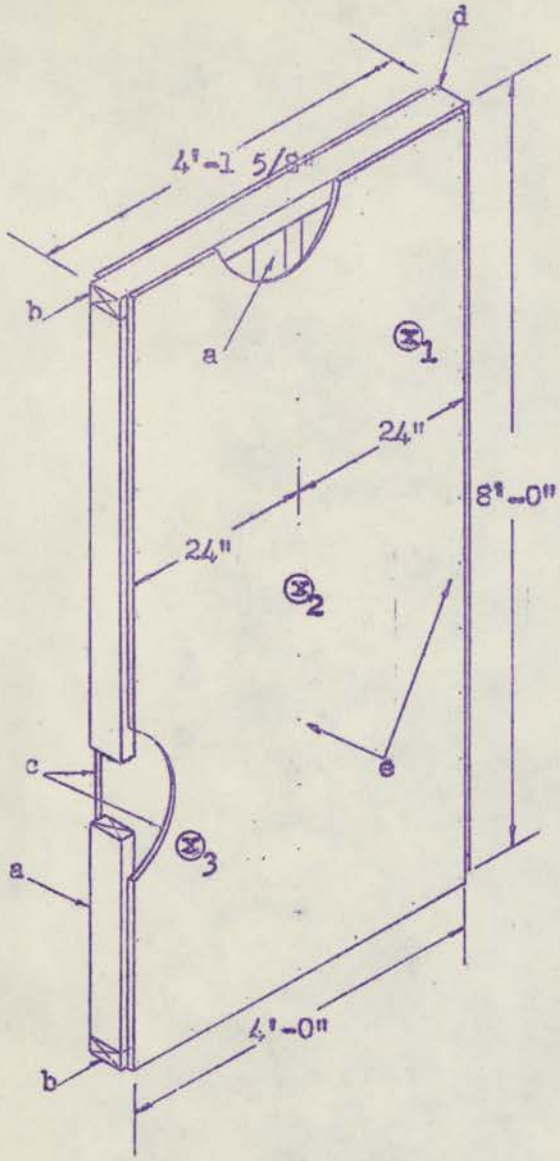
HT of Drop	REMARKS
42"	Unloaded Face: Plywood pulled through nails along outside stud. Loaded Face: Plywood pulled through nails directly under load.
48"	Unloaded Face: Plywood pulled through all nails along outside stud. Evidence of loaded stud cracking at support.
54"	Unloaded Face: Plywood pulled away from nails on outside and loaded studs. Loaded stud cracked at support.

* Unless otherwise noted cracks listed above were observed in the facing material only.

4" STUD WALL

1/2" gypsum board
2 sides studs, 24 oc

TEST PANEL DX
CLOSET WALL PROJECT
L.D.R.C.



a - 3 studs - 24" o. c.
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 1/2" gypsum board 4/0 x 8/0
nailed to both sides of stud

d - 16d common nails through
top and bottom plate - 2
per junction

e - 1 1/8" blue lath nails
8" o. c., 3/8" minimum
edge distance

Built: August 20, 1951
Trade Name: Certain-teed
Bestwall (c)

Mtls Cost/Sq.Ft.	26.6¢
Weight/Sq.Ft.	3.03#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 60" Impact Test
3. 15" Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.
⊗ - Subscript denotes test number.

TABULATION OF TEST RESULTS PANEL DX

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.040	.002
90#	.152	.032

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.375	.021
12	.672	.056
18	.875	.069
24	1.109	.131
30	1.359	.146
36	1.719	.262

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.469	.033
12	.703	.052
18	.906	.051
24	1.109	.065
30	1.297	.075
36	1.484	.085
36	1.547	.083

OBSERVATIONS OF DAMAGE ON PANEL DX *

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
30"	Unloaded Face: Crack 4' long adjacent to loaded stud.
36"	Above crack increased to 54". Loaded Face: Crack 12" long directly under load.

15# IMPACT TEST

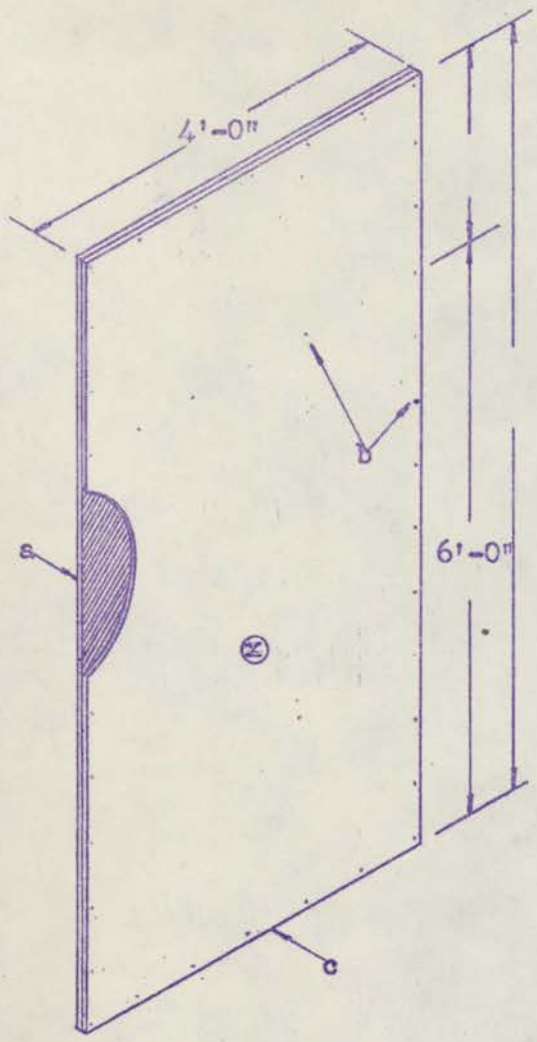
18"	Loaded Face: Crack 12" long directly under load.
24"	Above crack increased to 18".
30"	Above crack increased resulting in rupture of the wallboard. Crack 2' long developed adjacent to center stud.

* Unless otherwise noted cracks listed above were observed in the facing material only.

DOUBLE LAMINATE

1/2" Fiberboard
with linoleum paste

TEST PANEL FA
CLOSET WALL PROJECT
L.B.R.C..



a - 1/2" fiberboard 4/0 x 8/0.

b - Linoleum paste - 3/4 quarts /panel applied with a notched asphalt tile spreader.

c - 1/2" fiber board 4/0 x 8/0 laminated to "a".

d - 6d box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: September 10, 1951
Trade Name: Celotex (a) (c)
Wolverine Linoleum Paste (b)

Mtls Cost/Sq.Ft.	15.8¢
Weight/Sq.Ft.	1.8#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 15# Impact Test
3. Uniform Load Test
4. 60# Impact Test

⊗ - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL FA

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.264	.020
90#	.607	-

Uniform Load Test

Load	Deflection	Set
0#/sf	0	-
3.2	.172	-
13.2	.718	-
15	.828	-
18.2	.921	-
28.8	1.469	.168

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.531	.005
12	.718	.004
18	.671	.002
24	1.047	.009
30	1.031	.012
36	1.062	.016

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.640	.064
12	2.219	.128
18	2.656	.221
24	3.390	1.076
30	3.813	-

OBSERVATIONS OF DAMAGE ON PANEL FA

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
18"	Unloaded Face: Crack 6" long parallel to short span directly under load.
24"	Above crack increased to 2' and crack 12" long developed perpendicular to short span directly under load. Loaded Face: Crack 30" long parallel to short span directly under load.
30"	Unloaded Face: Slight rupture resulting on panel. Loaded Face: Crack 42" long parallel to short span. (extension of crack listed above).

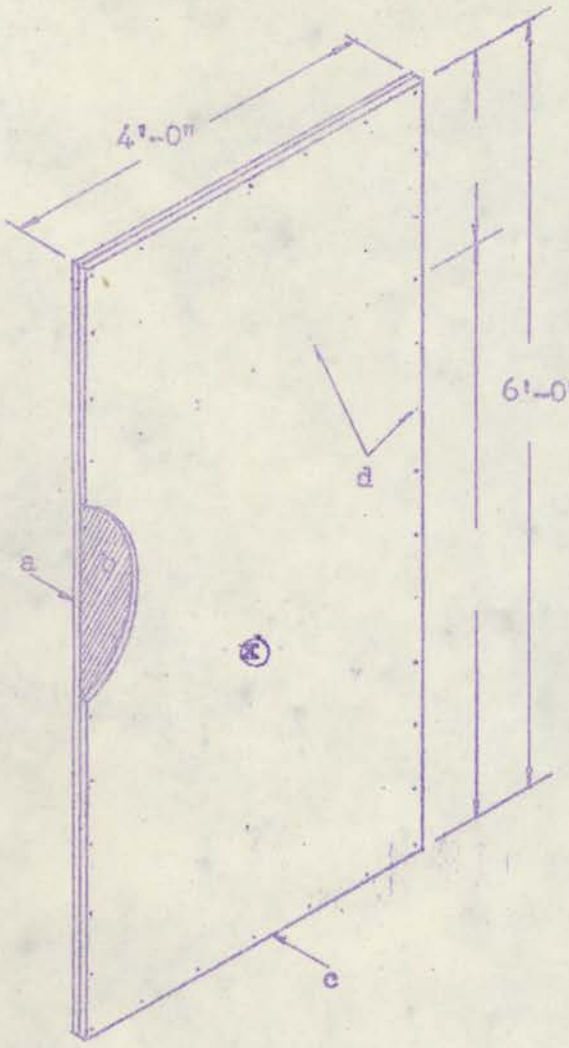
15# IMPACT TEST

36"	No apparent damage.

3/4" DOUBLE LAMINATE

3/8" gypsum board

TEST PANEL TC
CLOSET WALL PROJECT
L.D.R.C.



a - 3/8" gypsum board 4/0 x 8/0

b - Wallboard cement - 3 lbs/panel spread with a "V" notched trowel.

c - 3/8" gypsum board 4/0 x 8/0 laminated to "a"

d - 6d box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: October 1, 1951
Trade Name: Certain-teed Bestwall (a) (c) Perfatape Cement by U.S. Gypsum Co.

Matls Cost/Sq.Ft.	14.6¢
Wgt/Sq.Ft.	3.37#

Three specimens were tested in the following sequence:

1. Uniform Load Test
2. Concentrated Load Test
3. 15# Impact Load Test
4. 60# Impact Load Test

⊗ - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL FC

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.113	.012
90#	.402	.105

Uniform Load Test

Load	Deflection	Set
5#/sf	.109	-
10	.234	-
15	.406	-
20	.594	-
25	.797	-
30	.953	-
35	1.156	.319

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.359	.002
1/0	.516	.002
1/6	.594	.005
2/0	.687	.003
2/6	.781	.004
3/0	.906	.001
3/6	1.000	.015
4/0	.984	.020
4/6	1.016	.031

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.391	.068
1/0	1.828	.203
1/6	2.734	-

OBSERVATIONS OF DAMAGE ON PANEL FC

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
12"	Unloaded Face: Crack 30" long parallel to long span directly under load.
18"	Above crack increased to 46". Loaded Face: Crack 3" long parallel to long span directly under load.

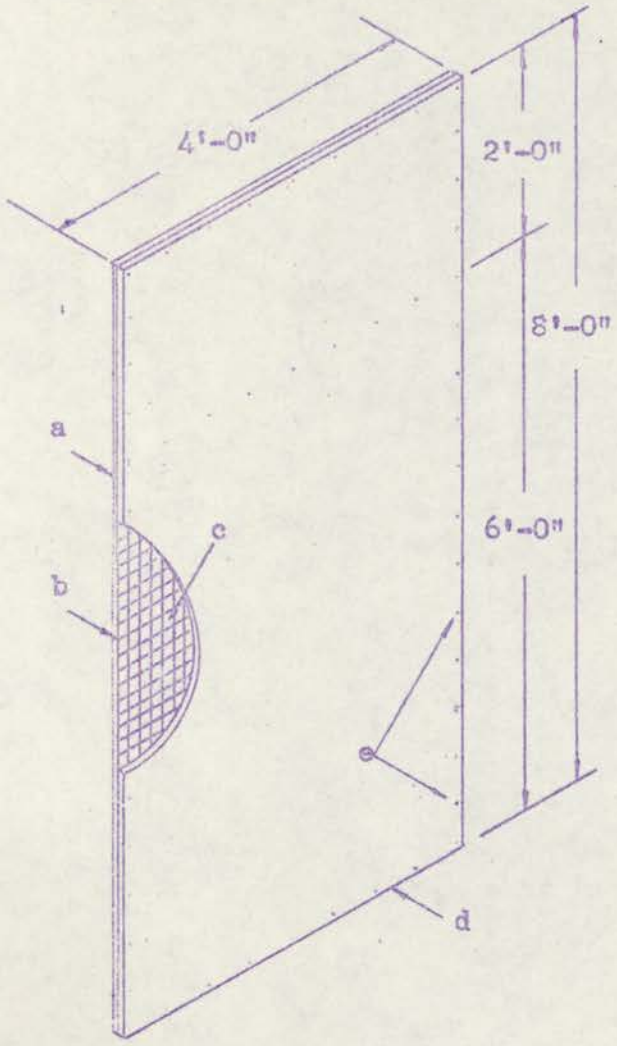
15# IMPACT TEST

54"	No apparent damage.

REINF'D DOUBLE LAMINATE

1/2" gypsum board
2 sides, chicken wire

TEST PANEL K
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0.

b - 1" hexagon mesh 20 ga. galvanized chicken wire.

c - Wallboard cement - 6 lbs/panel spread with a "V" notched trowel.

d - 1/2" gypsum board 4/0 x 8/0.

e - 6d box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: August 29, 1951
Trade Name: Certain-teed Best Wall (a) (d)
Perf-a-Type Cement by U.S. Gypsum Company

Matls Cost/Sq.Ft. 18.2¢
Weight/Sq.Ft. 4.6#

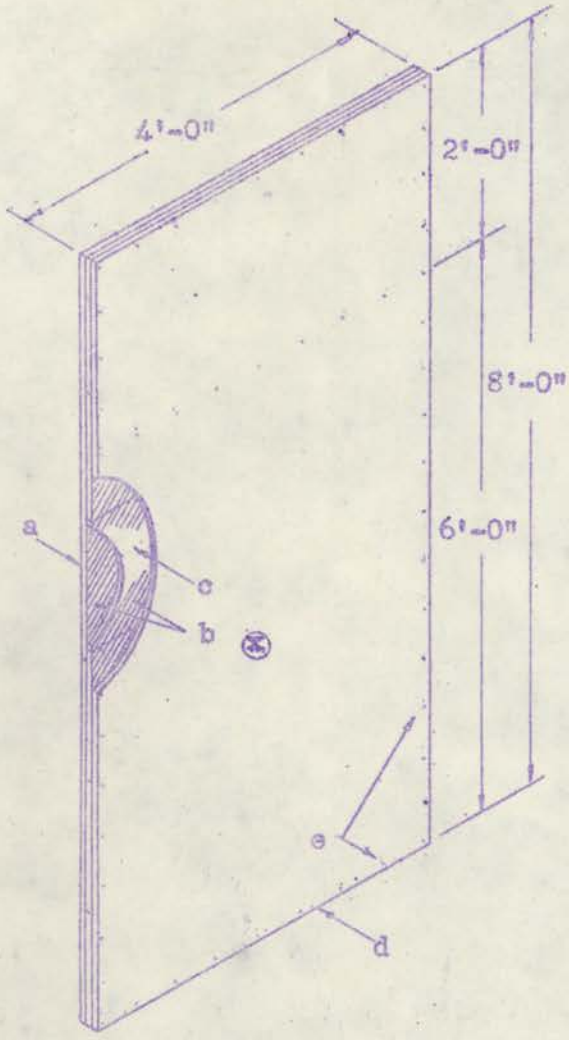
Panel was not tested.

Panel was not tested as the lamination process proved unsuccessful.

1 1/2" TRIPLE LAMINATE

gypsum board both sides gypsum lath

TEST PANEL L
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0.

b - Wallboard cement - 3 lbs/ panel spread with a "V" notched trowel.

c - 6 pcs. 3/8" x 16" x 48" gypsum board lath laminated to "a".

d - 3/8" gypsum board 4/0 x 8/0 laminated to "c".

e - 6d box nails 6" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: August 29, 1951
Trade Name: Certain-teed
Bestwall (a) (d)
Perf-a-type Cement
by U.S. Gypsum Co.(b)
Gold Bond (c)
C

MtlsCost/Sq.Ft.	19.8¢
Weight/Sq.Ft.	5.37#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 60# Impact Load Test

⊗ - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL L

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.021	.001
90#	.050	.005

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.593	.047
12	.984	.087
18	1.375	.141
24	1.687	.190
30	1.984	.288
36	2.375	.447

OBSERVATIONS OF DAMAGE ON PANEL L

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

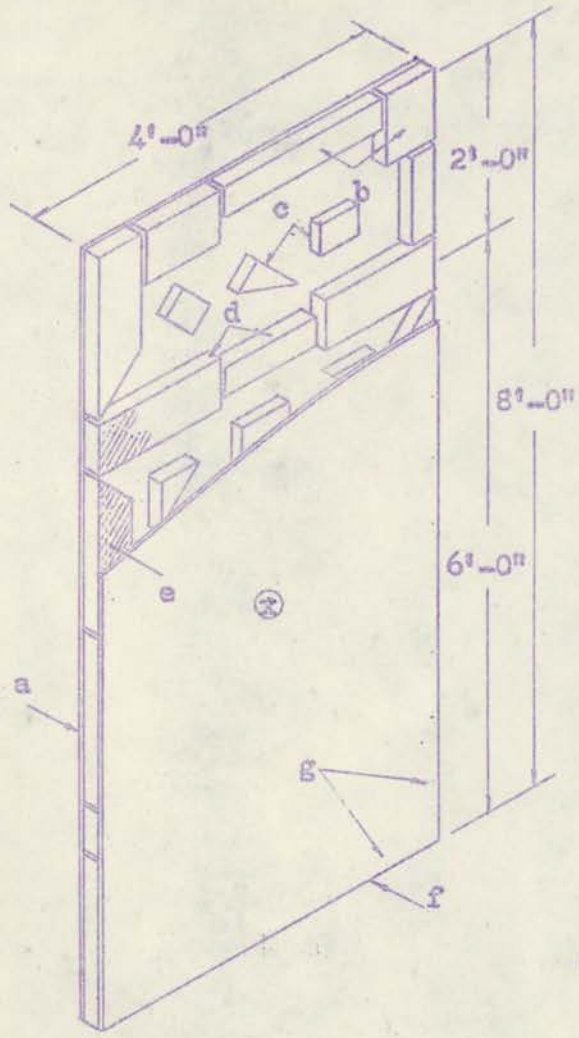
No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
24"	Unloaded Face: 1" crack directly under load.
30"	Above crack increased to 12".

1 3/4" HOLLOW CORE
1/2" gypsum board, 2 sides
1" wood scrap

TEST PANEL H
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0

b - 1" wood scrap edge strips, continuous, with 1/2" maximum space between blocks, glued to "a"

c - 18 pcs. of 1" wood scrap center blocking, minimum area 4 sq. in. (Note: any piece 12" long equal to 2 pieces) glued to "a"

d - 1" wood scrap shelf backing with 1/2" maximum space between blocks glued to "a"

e - Powder glue - 1/2 pound was mixed with water and applied.

f - 1/2" gypsum board 4/0 x 8/0 glued to "b", "c", and "d"

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet materials weighing 10 lbs/sq.ft. or more.

g - 8d common nails 6" o.c., 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

One specimen was tested in the following sequence:

1. Concentrated load test
2. 60# impact test

⊼ Indicates axis of load
◯ Indicates axis of deflection and set readings

Built: August 29, 1951
Trade Name: Certain-teed Bestwall (a) & (f)
Weldwood Glue (e)

Mtls Cost/Sq.Ft.	16.2¢
Weight/Sq.Ft.	5.31#

TABULATION OF TEST RESULTS PANEL H

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.097	.009
90#	.244	.047

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.828	.111
12	1.516	.329
18	2.234	.877

OBSERVATIONS OF DAMAGE ON PANEL H

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

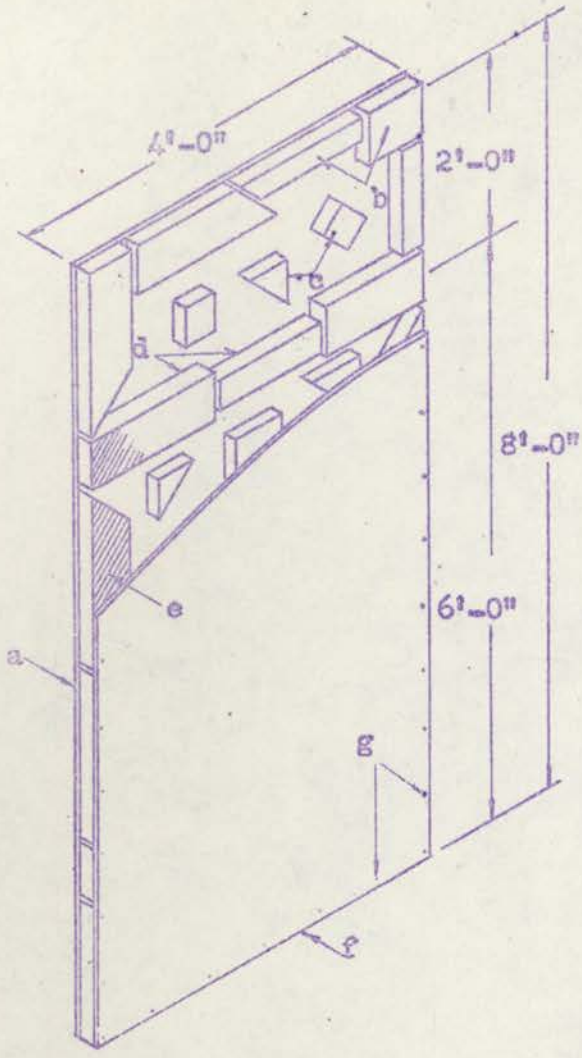
60# IMPACT TEST

HT of Drop	REMARKS
6"	Unloaded Face: Crack 2' long directly under load parallel to long span.
12"	The above crack increased to 5'.
18"	Loaded Face: Large crack developed directly under load. Unloaded Face: Above crack increased to 6'.

2 3/4" HOLLOW CORE

1/2" gypsum board, 2 sides
2" wood scrap

TEST PANEL I
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0

b - 2" wood scrap edge strips, continuous, with 1/2" maximum space between blocks, glued to "a"

c - 18 pcs. of 2" wood scrap center blocking, minimum area 4 sq. in. (Note: any piece 12" long equal to 2 pieces) glued to "a"

d - 2" wood scrap shelf backing with 1/2" maximum space between blocks, glued to "a"

e - Powder glue - 1/2 pound was mixed with water and applied.

f - 1/2" gypsum board 4/0 x 8/0 glued to "b", "c", and "d"

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet materials weighing 10 lbs/sq.ft. or more.

g - 8d common nails 6" o.c., 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: August 29, 1951
Trade Name: Certain-teed Bestwall (a) & (f)
Weldwood Glue (e)

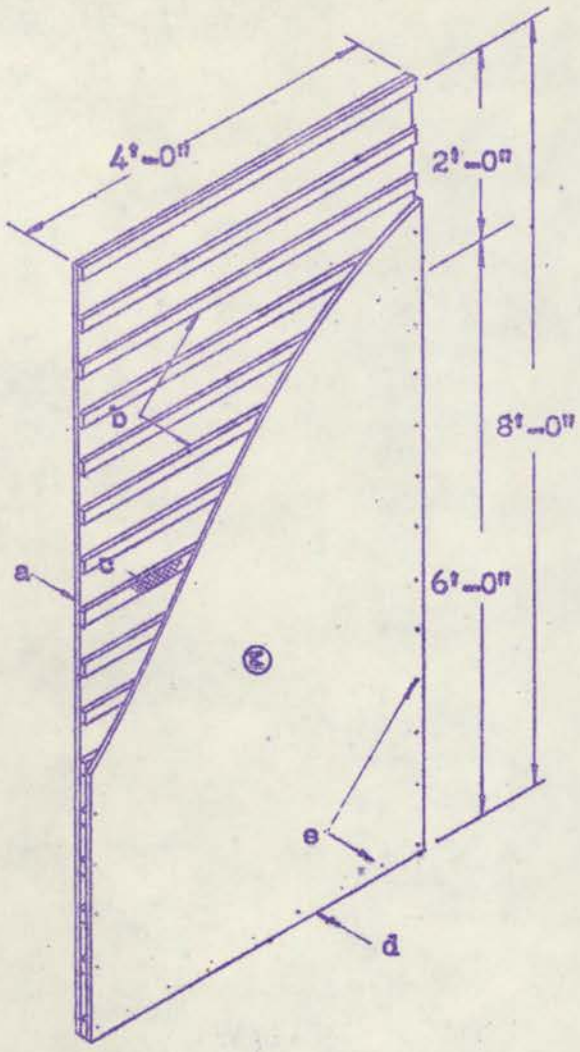
Mtls Cost/Sq.Ft.	16.2¢
Weight/Sq.Ft.	6.12#

Panel was not tested

Before the specimen could be tested serious delamination occurred resulting in separation of wood scrap and gypsum facings. In addition, panel H, (similar construction, utilizing wood scrap 1" thick instead of 2" thick) observed under the three test loads proved unsatisfactory.

3/8" HOLLOW CORE
1/2" gypsum board, 2 sides
wood lath 6" oc

TEST PANEL J
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0

b - 3/8" x 1 1/2" wood lath 6" o.c. glued to "a"

c - Powder glue - 2 pounds were mixed with water and applied.

d - 1/2" gypsum board 4/0 x 8/0

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet materials weighing 10 lbs/sq.ft. or more.

e - 6d box nails 6" o.c., countersunk 1/2", 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: August 29, 1951
Trade Name: Certain-teed Bestwall (a) & (d)
Weldwood Glue (c)

Mtls Cost/Sq.Ft.	21.4¢
Weight/Sq.Ft.	4.81#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL J

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.030	.005
90#	.076	.015

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.641	.042
12	1.219	.131
18	1.781	.266
24	1.359	.596
30	3.734	1.106
36	4.297	-

OBSERVATIONS OF DAMAGE ON PANEL J

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

60# IMPACT TEST

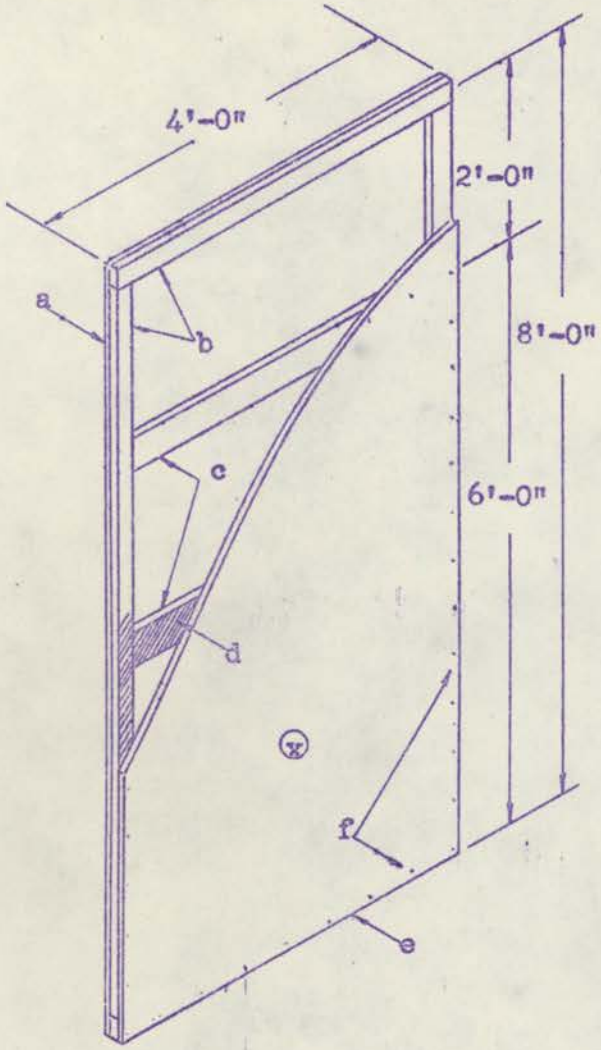
HT of Drop	REMARKS
24"	Loaded Face: Crack 6" long developed directly under load. ("Y" shaped, 6" legs).
30"	Above crack increased to 2'. "Y" branches increased to 1'. Unloaded Face: Crack 4' long ((width of short span) developed directly under load causing rupture in gypsum board.

(Inspection of the panel after the 60# impact test revealed that the wood lath adhered less than 50% to the gypsum board facing material.)

1 3/4" HOLLOW CORE

1/2" gypsum board
2 sides, 1 x 4's, 24" oc

TEST PANEL N
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0.

b - 1 x 2 #3 yellow pine around perimeter glued to "a" with weldwood glue.

c - 3 pcs. 1 x 4 #3 yellow pine 24" o.c. glued to "a" with weldwood glue.

d - Powder glue - 1/2 pound was mixed with water and applied.

e - 1/2" gypsum board 4/0 x 8/0 glued to "b" and "c" with weldwood glue.

f - 8d box nails 6" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet materials weighing 10 lbs/sq.ft. or more.

Built: August 29, 1951
Trade Name: Certain-teed Best Wall (a) (e)
Weld Wood Glue (d)

Mtls Cost/Sq.Ft.	16.2¢
Weight/Sq.Ft.	5.03#

One specimen was tested in the following sequence:

1. Concentrated load test
2. 60# Impact Test

x - Indicates axis of load
○ - Indicates axis of deflection and set reading

TABULATION OF TEST RESULTS PANEL N

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.024	.000
90#	.045	.005

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.500	.028
12	.860	.094
18	1.344	.150
24	1.891	.221
30	2.766	.435

OBSERVATIONS OF DAMAGE ON PANEL N

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

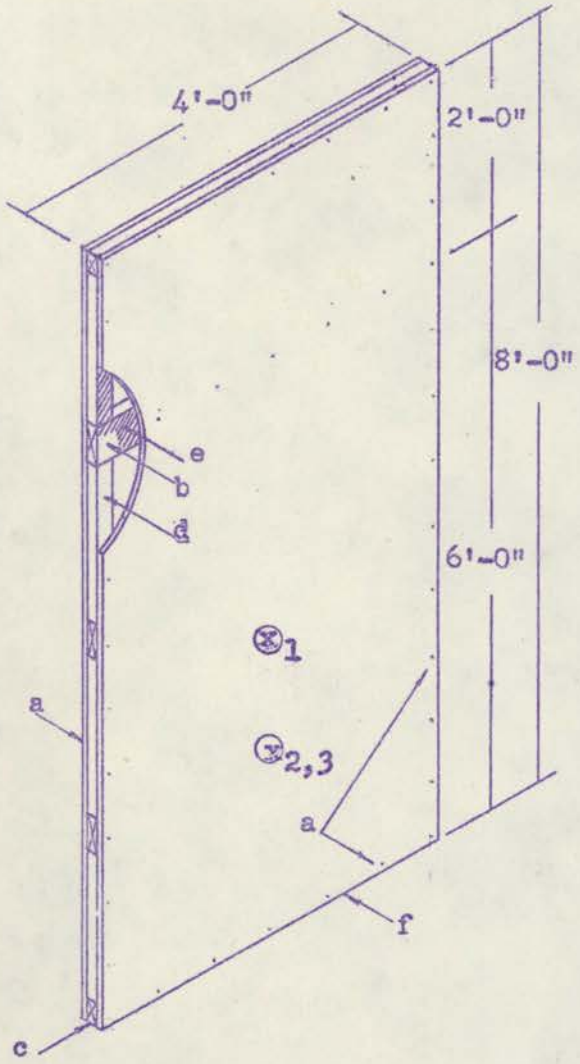
60# IMPACT TEST

HT of Drop	REMARKS
18"	Two crack 4' and 2' in length directly under load.
24"	The above cracks increased to 5½' and 2½'.
30"	The above cracks increased. Unloaded Face: Large crack developed resulting in rupture of the gypsum board.

1 3/4" HOLLOW CORE

3/8" Gypsum Board
2 sides, 1 x 4's, 24" o.c.

TEST PANEL NA
WALL CLOSET PROJECT
L.B.R.C.



a - 3/8" gypsum board 4/0 x 8/0 cemented to 'b' & 'c' & 'd'.

b - 1" x 4" - #3 yellow pine 24" o.c. - 48" long - cemented to 'a' & 'f'.

c - 1" x 2" - #2 yellow pine 48" long - top & bottom strips - cemented to 'a' & 'f'.

d - 1" x 2" - #2 yellow pine edge strips - cemented to 'a' & 'f'.

e - Linoleum paste - 7/8 quarts/ panel applied with a notched asphalt tile spreader.

f - 3/8" gypsum board 4/0 x 8/0 cemented to 'b', 'c', & 'd'.

g - 8d common nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above three layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: October 20, 1951
Trade Name: U.S.G. Sheetrock (a) (f)
Wolverine Linoleum Paste (e)

Mtls Cost/Sq.Ft.	14.0¢
Weight/Sq.Ft.	3.62#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. Uniform Load Test
3. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL NA

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.119	.0215
90#	.536	.202

Uniform Load Test

Load	Deflection	Set
5#/sf	.031	-
10	.078	-
15	.141	-
20	.219	-
25	.281	-
30	.375	-
35	.484	.123

15# Impact Test

Ht. of Drop	Deflection	Set
5"	.033	-
10	.082	-
15	.136	-
20	.209	-
25	.282	-
30	.379	-
35	.473	.127

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.641	.018
1/0	1.031	.052
1/6	1.469	.083
2/0	1.797	.109
2/6	2.047	.144
3/0	2.422	-

OBSERVATIONS OF DAMAGE ON PANEL NA

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

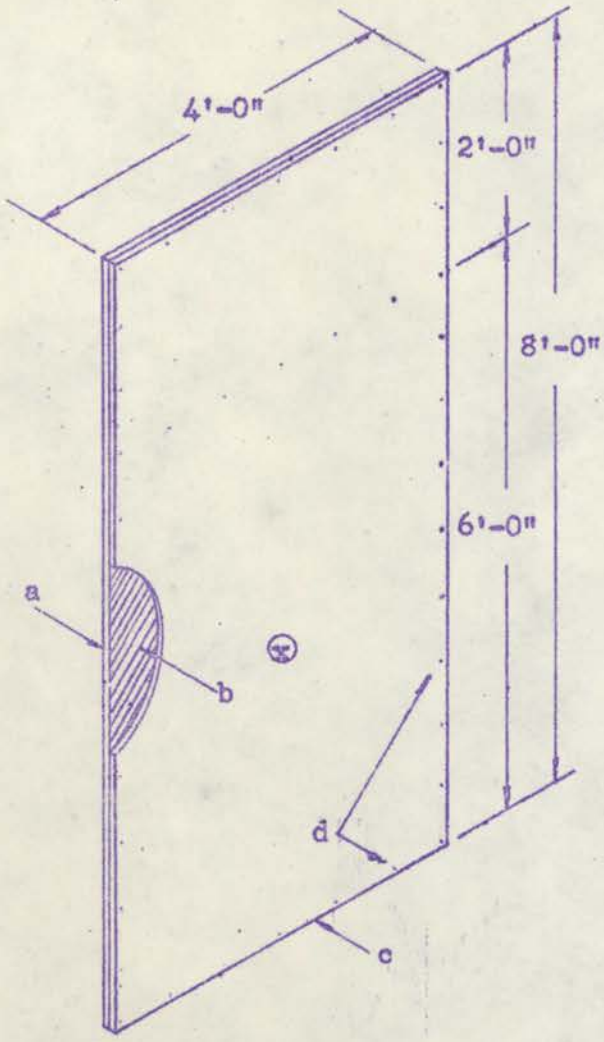
HT of Drop	REMARKS
30"	Unloaded Face: Crack 12" long parallel to short span directly under load. Loaded Face: Semi-circular crack 6" long directly under load.
36"	Unloaded Face: Above crack increased to 3'.

(Inspection of the panel after the 60# impact test revealed that the loaded 1 x 4 adhered less than 50% to the gypsum board.)

5/8" THIN WALL

1/8" tempered hardboard
and 1/2" gypsum board

TEST PANEL O
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" tempered hardboard 4/0 x 8/0.

b - Powder glue - 3 1/2 pounds were mixed with water and applied.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a" with weld-wood glue.

d - 4d coated box nails 6" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet materials weighing 10 lbs/sq. ft. or more.

Built: August 29, 1951
Trade Name: Masonite (a)
Weld Wood Glue (b)
Certain-teed
Bestwall (c)

Mtls Cost/Sq.Ft.	26.7¢
Weight/Sq.Ft.	3.03#

Three specimens were tested in the following sequence:

1. Concentrated Load Test
2. 50# Impact Load Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL O

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentaion	Set
40#	.096	.014
90#	.218	.032

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.016	.005
12	1.266	.016
18	1.766	.015
24	1.797	.004
30	2.000	.001
36	2.094	.005

OBSERVATIONS OF DAMAGE ON PANEL O

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

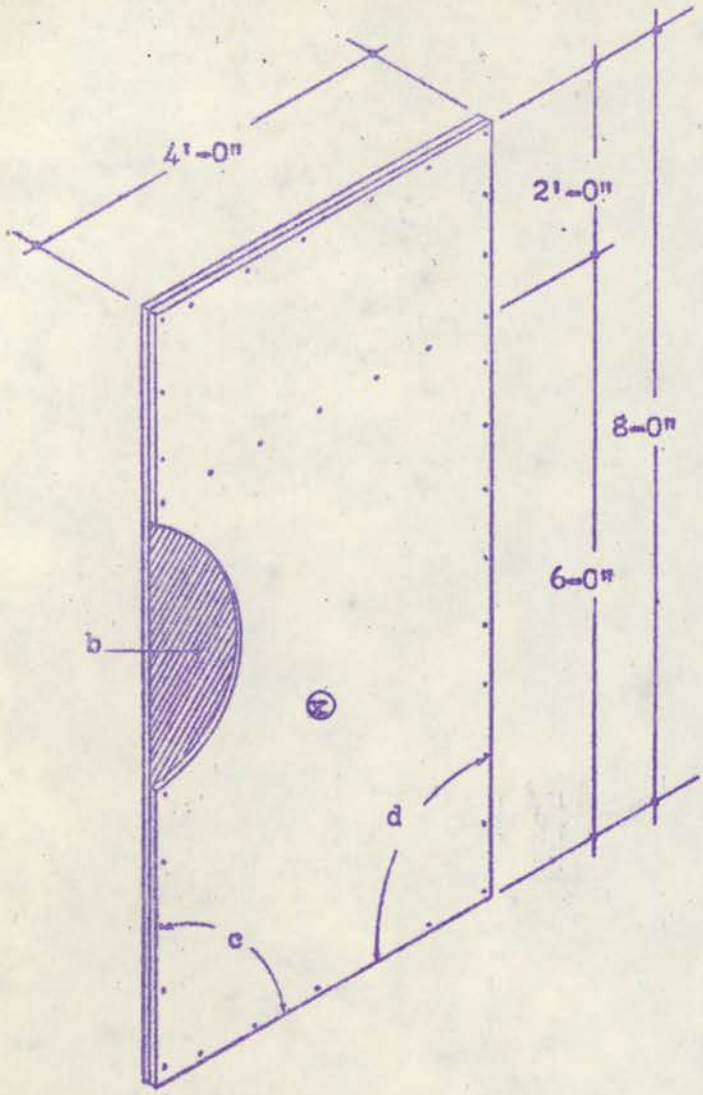
60# IMPACT TEST

HT of Drop	REMARKS
36"	No apparent damage.

TEST PANEL 0A
CLOSET WALL PROJECT
L.D.R.C.

5/8" THIN WALL

1/8" Tempered hardboard
and 1/2" gypsum board



a - 1/8" tempered hardboard 4/0 x 8/0.

b - Linoleum paste - 3/4 quarts/panel applied with a notched asphalt tile spreader.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a" with linoleum paste.

d - 4d coated box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: September 10, 1951
Trade Name: Masonite (a)
Wolverine Linoleum Paste #30 (b)
U.S. Gypsum Sheetrock (c)

Mtls Cost/Sq.Ft.	19.3¢
Weight/Sq.Ft.	3.03#

One specimen was tested in the following sequence:

1. Concentrated load test.
2. 15# Impact Test
3. ~~Uniform Test~~
4. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL 0A

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.097	.008
90#	.218	.015

Uniform Load Test

Load	Deflection	Set
0#/sf	0	-
8.7	.203	-
12.0	.281	-
15.0	.375	-
17.0	.422	-
30.7	.750	.084

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.313	.004
12	.421	.002
18	.469	.003
24	.547	.005
30	.594	.008
36	.688	.010

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.109	.030
12	1.437	.088
18	1.750	.140
24	1.984	.177
30	2.187	.214
36	2.359	.239
42	2.547	.289
48	2.687	.331
54	2.859	.388

OBSERVATIONS OF DAMAGE ON PANEL 0A

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
48"	Evidence of 1 x 2 perimeter strip pulling away from test frame. (However, 1 x 2 perimeter strip used previously in approximately 10 tests).

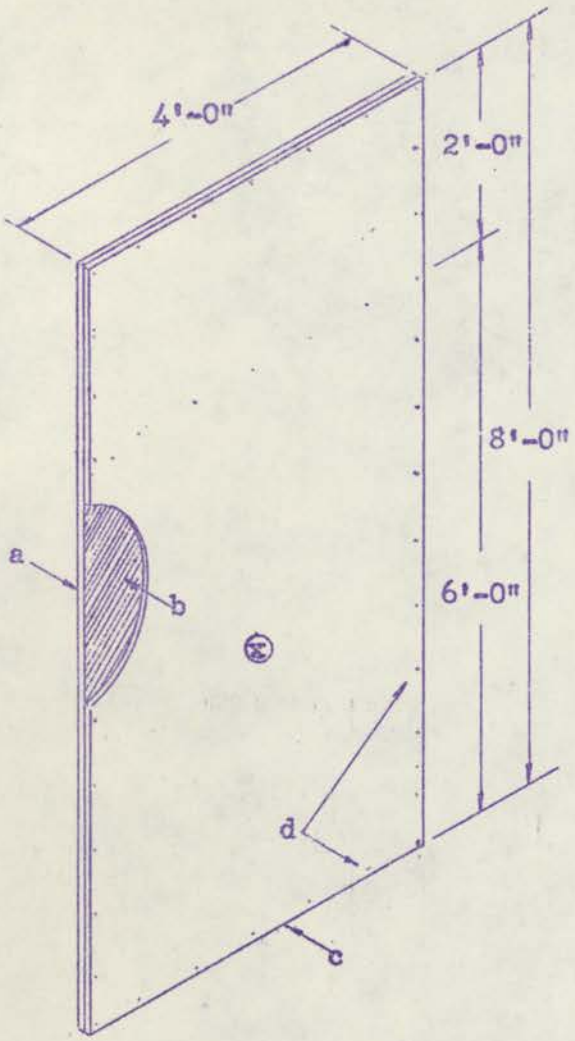
15# IMPACT TEST

No apparent damage.

5/8" THIN WALL

1/8" tempered hardboard
and 1/2" fiber board

TEST PANEL OR
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" tempered hardboard 4/0 x 8/0

b - Linoleum paste - 3/4 quarts/ panel applied with a notched asphalt tile spreader.

c - 1/2" fiber board 4/0 x 8/0 laminated to "a" with linoleum paste.

d - 4d coated box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: September 10, 1951

Trade Name: Masonite (a)
Wolverine Linoleum Paste (b)
Celotex (c)

Mtls Cost/Sq.Ft.	19.3¢
Weight/Sq.Ft.	1.6#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 15" Impact Test
3. Uniform Load Test
4. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and not readings.

TABULATION OF TEST RESULTS PANEL OB

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.222	.030
90#	.513	.061

Uniform Load Test

Load	Deflection	Set
13.4#/sf	.688	-
15	.750	-
18.4	.859	-
32.1	1.234	.156

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.531	.009
12	.687	.013
18	.797	.020
24	.844	.030
30	1.015	.029
36	1.125	.030

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.375	.026
12	1.797	.059
18	2.109	.083
24	2.344	.125
30	2.625	.201
36	3.281	.227
42	3.844	.841
48	4.703	

OBSERVATIONS OF DAMAGE ON PANEL OB

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS
30"	Loaded Face: Fiberboard pulled through one nail 3' from bottom of the panel.
36"	Unloaded Face: Crack 6" long extending from loose nail.
42"	Unloaded Face: Above crack extended to 12". Loaded Face: Fiberboard pulled through five nails causing buckling 3' from the bottom of the panel.
48"	Loaded Face: Crack 18" long extending from loose nails resulting in rupture of the fiberboard.

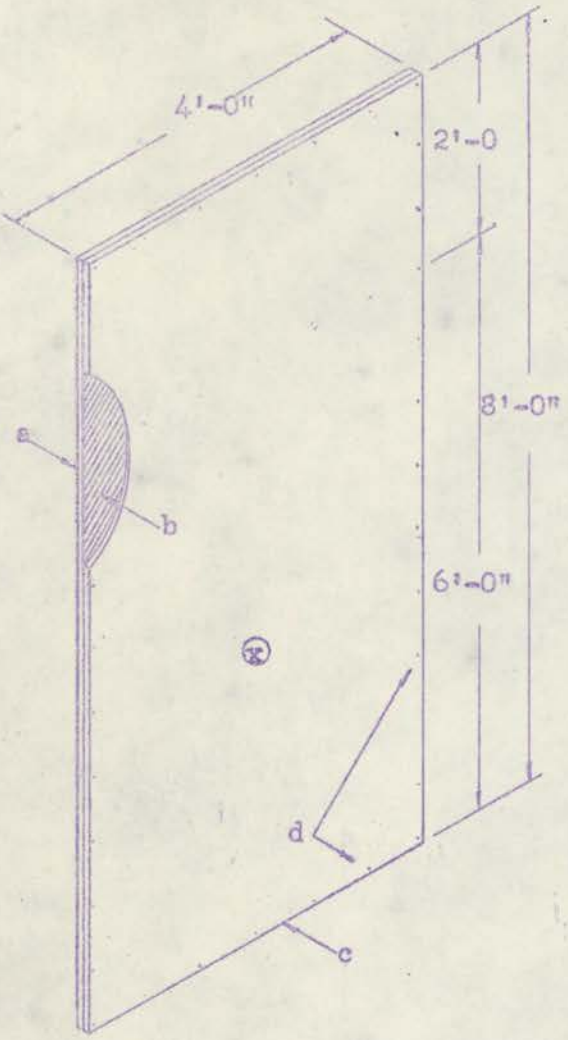
15# IMPACT TEST

36"	No apparent damage.

1/2" THIN WALL

1/8" tempered hardboard
and 3/8" gypsum board

TEST PANEL GG
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" tempered hardboard 4/0 x 8/0.

b - Linoleum paste - 1 quart/ panel applied with a notched asphalt tile spreader.

c - 3/8" gypsum board 4/0 x 8/0 laminated to "a" with linoleum paste.

d - 4d coated box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: September 10, 1951
Trade Name: Masonite (a)
U.S. Gypsum Co.
Sheetrock (c)
Wolverine Linoleum Paste (b)

Mtls Cost/Sq.Ft.	21.7¢
Weight/Sq.Ft.	2.34#

Two specimens were tested in the following sequence:

1. Concentrated on the gypsum side
2. Uniform on the gypsum side
3. 15" Impact on the gypsum side
4. 60" Impact on the gypsum side
5. 15" Impact on the hardboard side
6. 60" Impact on the hardboard side

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL OC
Specimen No. 1
(Two Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.156	.009
90#	.335	.023

Uniform Load Test

Load	Deflection	Set
2.7#/sf	.156	-
12.7	.578	-
15	.641	-
17.7	.719	-
31.4	1.078	.160

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.375	.008
12	.547	.013
18	.641	.014
24	.734	.023
30	.797	.028
36	.859	.036

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.203	.033
12	1.531	.064
18	1.844	.101
24	2.047	.132
30	2.156	.221
36	2.828	.351
42	3.297	-

TABULATION OF TEST RESULTS PANEL OC

Specimen No. 2

(Two Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.130	.011
90#	.271	.029

Uniform Load Test

Load	Deflection	Set
5#/sf	.109	-
10	.281	-
15	.406	-
20	.531	-
25	.672	-
30	.797	-
35	.922	.235

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.297	.002
1/0	.391	.006
1/6	.453	.004
2/0	.500	.010
2/6	.609	.006
3/0	.672	.004
3/6	.703	.004
4/0	.734	.007
4/6	.734	.006
4/6	.875	.004

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.078	.014
1/0	1.359	.025
1/6	1.609	.032
2/0	1.797	.054
2/6	1.969	.070
3/0	2.093	.079
3/6	2.234	.113
4/0	2.390	.138
4/6	2.531	.159

OBSERVATIONS OF DAMAGE ON PANEL OC

(Two specimens built and tested)

	Specimen No. 1		Specimen No. 2
CONCENTRATED LOAD TEST			
	No apparent damage.		No apparent damage.
UNIFORM LOAD TEST			
	No apparent damage.		No apparent damage.
60# IMPACT TEST (Gypsum board face)			
HT of Drop	REMARKS	HT of Drop	REMARKS
30"	Two nails pulled loose 3' from bottom edge of panel.	54"	Loaded Face: Wrinkling of gypsum board 12" long radiating from bottom corners.
36"	Loaded Face: Crack 12" long developed at pulled nails.		
42"	Loaded Face: Buckling of panel 3' from botton edge resulting from crack at pulled nails.		
15# IMPACT TEST (Gypsum board face)			
36"	No apparent damage.	54"	No apparent damage.
60# IMPACT TEST (Hardboard face)			
	Not tested.	6"	Several nails pulled along 4' edge.
		12"	Nails continued to pull (1/8" to 1/4").
		18"	½" buckling resulted between two nails.
		24"	Loaded Face: Crack 3" long radiating from bottom corner of panel.
		30"	Above crack increased 12" radiating toward the center of the panel.
		36"	Above crack increased and an additional crack developed parallel to the short span directly under load.

(Continued)

(Continued)

OBSERVATIONS OF DAMAGE ON PANEL CC

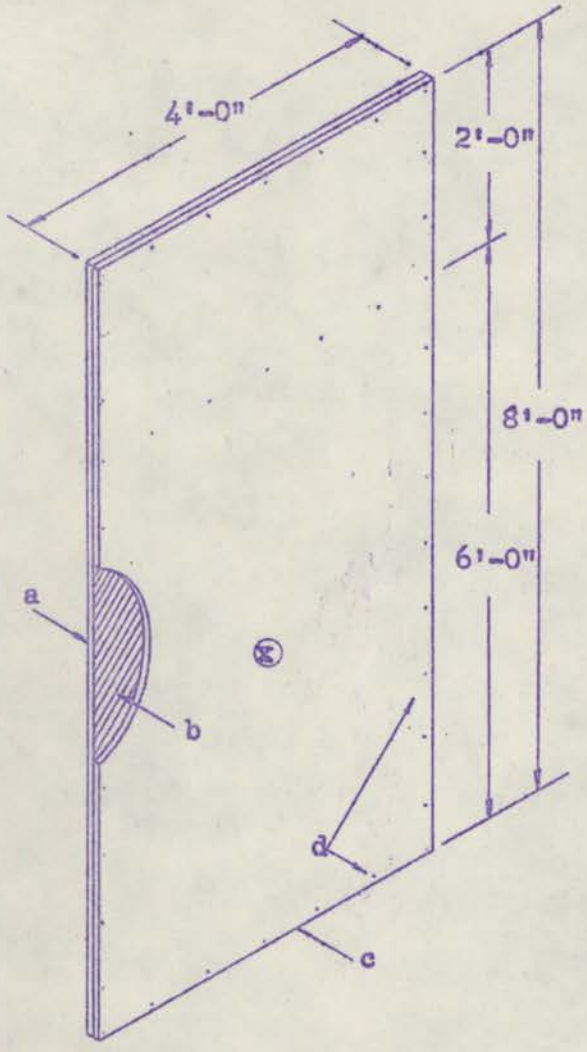
(Two specimens built and tested)

	Specimen No. 1	Specimen No. 2
15# IMPACT TEST (Hardboard face)		
	Not tested	No apparent damage.

5/8" THIN WALL

1/8" untempered hardboard
and 1/2" gypsum board

TEST PANEL OF
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" untempered hardboard 4/0 x 8/0.

b - Linoleum paste - 1 1/8 quarts/panel applied with a notched asphalt tile spreader.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a" with linoleum paste.

d - 4d coated box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: October 1, 1951
Trade Name: Wolverine Linoleum Paste #30 (b)
Bestwall (c)

Mtls Cost/Sq.Ft.	17.7¢
Weight/Sq.Ft.	3.03#

One specimen was tested in the following sequence:

1. Concentrated on the gypsum side
2. Uniform on the gypsum side
3. 15# Impact on the gypsum side
4. 60# Impact on the gypsum side
5. 15# Impact on the hardboard side

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL CF

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.173	.035
90#	.467	.136

Uniform Load Test

Load	Deflection	Set
5#/sf	.109	-
10	.234	-
15	.344	-
20	.453	-
25	.547	-
30	.656	-
35	.750	.130

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.234	.001
1/0	.359	.001
1/6	.422	.001
2/0	.359	.002
2/0	.469	.002
2/6	.516	.001
3/0	.562	.005
3/6	.578	.006
4/0	.578	.008
4/6	.625	.012
4/6	.703	.011

60# Impact Test

Ht. of Drop	Deflection	Set
6"	.922	.006
1/0	1.187	.023
1/6	1.359	.027
2/0	1.562	.028
2/6	1.687	.033
3/0	1.828	.046
3/6	2.000	.047
4/0	2.172	.060
4/6	2.187	.057

OBSERVATIONS OF DAMAGE ON PANEL OF

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST (on gypsum board side)

HT of Drop	REMARKS
42"	Loaded face: 6 nails pulled through panel directly at perimeter strip adjacent to load.

15# IMPACT TEST (on gypsum board side)

No apparent damage.

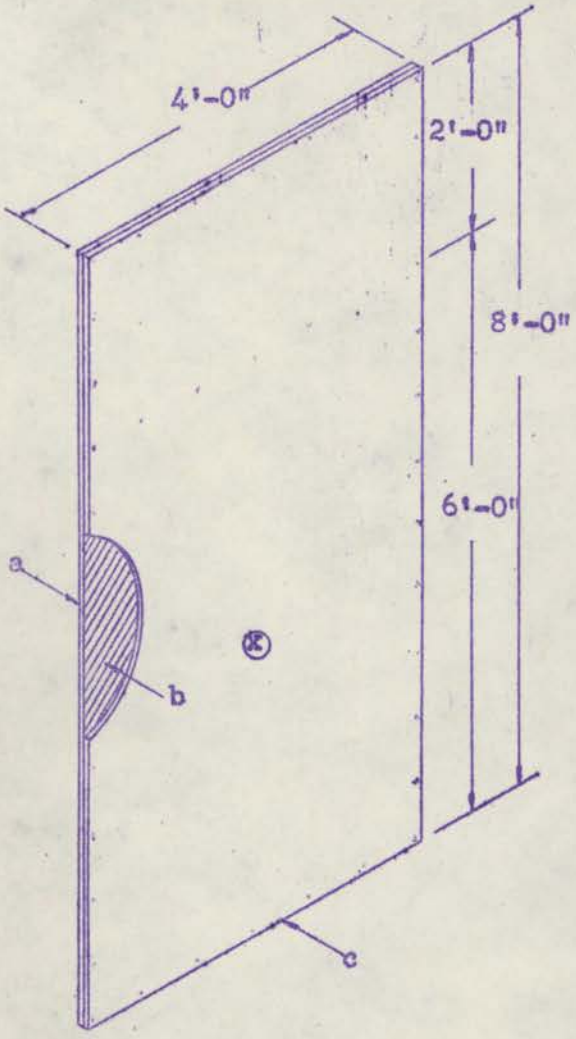
15# IMPACT TEST (on hardboard side)

36"	Loaded face: Two cracks developed parallel to long span 6" in length near point of impact.
42"	Above cracks increased to bottom edge of panel. (24" in length).
48"	Evidence of numerous nail failures (i.e. nails pulled from $\frac{1}{2}$" to 1" along short span and long span and along shelf strip).

5/8" THIN WALL

1/2" gypsum board
and 5/32" pulp board

TEST PANEL ON
CLOSET WALL PROJECT
L.D.R.C.



a - 5/32" paper pulp board 4/0 x 8/0

b - Linoleum paste - 3/4 quarts/ panel applied with a notched asphalt tile spreader.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a" with linoleum paste.

d - 4d coated box nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: October 1, 1951
Trade Name: Chippewa Board (a)
Wolverine Linoleum Paste No.30 (b)
Best Wall (c)

Mtls Cost/Sq.Ft.	14.8¢
Weight/Sq.Ft.	2.81#

One specimen was tested in the following sequence:

1. Concentrated on the gypsum side
2. Uniform on the gypsum side
3. 15# Impact on the gypsum side
4. 60# Impact on the gypsum side
5.
6. 60# Impact on the pulpboard side

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL OH

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.117	.004
90#	.247	.062

Uniform Load Test

Load	Deflection	Set
5#/sf	.094	-
10	.234	-
15	.359	-
20	.484	-
25	.609	-
30	.688	-
35	.781	-

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.266	.002
12	.422	.007
18	.562	.007
24	.625	.012
30	.719	.013
36	.766	.015
42	.797	.020
48	.844	.013
54	.922	.024
54	1.00	.030

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.109	.027
12	1.484	.051
18	1.750	.084
24	2.016	.127
30	2.234	.166
36	2.469	.211
42	2.625	.264
48	2.812	.313
54	2.937	.344

OBSERVATIONS OF DAMAGE ON PANEL CH

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage. However, from an esthetic view point the panel is too flimsy (i.e. it quivered at the center when hit a light blow with a hand).

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST (On gypsum board side)

42" Loaded Face: Crease 30" long along shelf strip.

15# IMPACT TEST (On gypsum board side)

No apparent damage.

60# IMPACT TEST (Pulp board side)

6" Loaded Face: Crack 6" long directly under load.

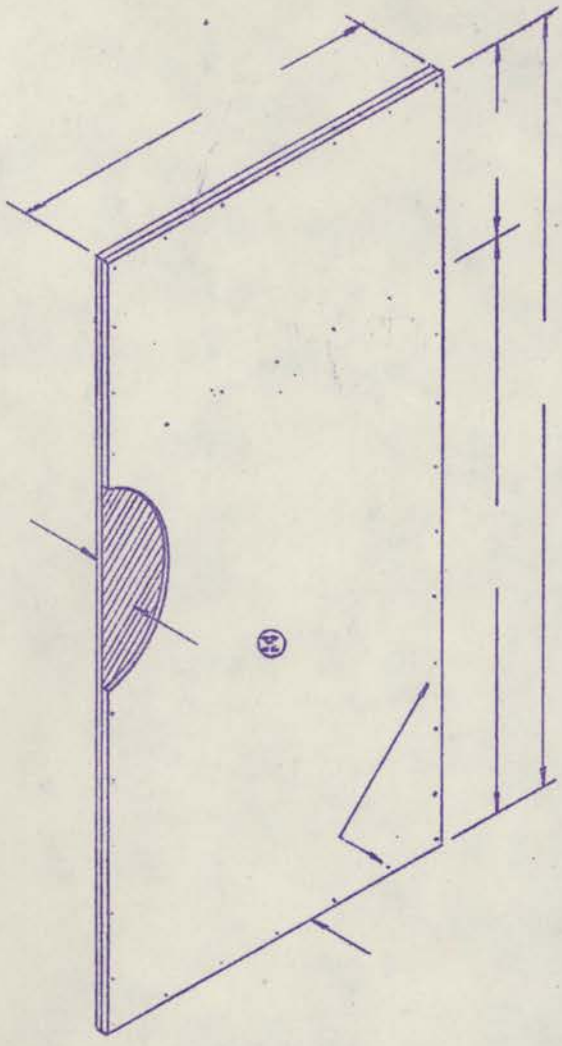
12 - 18" Under subsequent drop the above crack increased.

24" Loaded Face: Panel pulled through nails at the shelf strip. (3/4").

1" VARIED LAMINATE

1/2" fiberboard and
1/2" gypsum board

TEST PANEL OE
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" fiberboard 4/0 x 8/0

b - Wallboard cement - 12 lbs/ panel soread with a "V" notched trowel.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a".

d - 6d coated box nails 8" oc 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

Built: September 10, 1951
Trade Name: Celotex (a)
Perf-a-tyne Cement by U.S. Gypsum Co.(b)
U.S. Gypsum Sheetrock (c)

Mtls Cost/Sq.Ft.	21.3¢
Weight/Sq.Ft.	3.2#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. 15# Impact Test
3. Uniform Test
4. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL OE

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.116	.009
90#	.308	.041

Uniform Load Test

Load	Deflection	Set
1.8#/sf	0	-
11.8	.281	-
15	.390	-
16.8	.421	-
30.5	.859	.135

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.313	.006
12	.438	.019
18	.516	.012
24	.594	.006
30	.656	.004
36	.719	.008

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.281	.064
12	1.734	.118
18	2.078	.193
24	2.453	.304
30	2.921	-

OBSERVATIONS OF DAMAGE ON PANEL OE

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

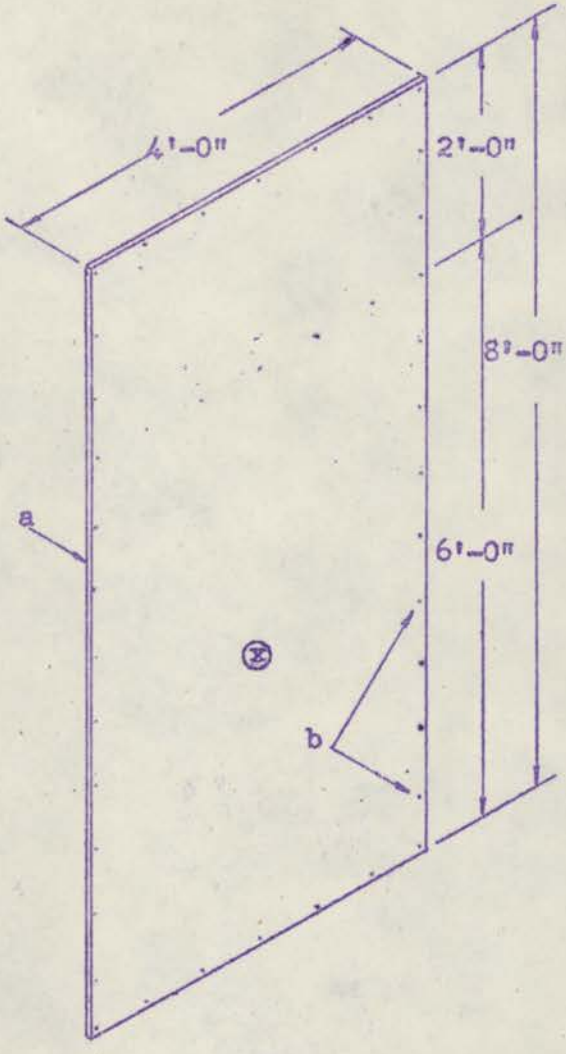
HT of Drop	REMARKS
24"	Unloaded Face: Circular crack 6" long directly under load.
30"	Loaded Face: Crack increased to 18" parallel to the short span directly under load.

15# IMPACT TEST

No apparent damage.

5/8" PLYWOOD
5/8" plywood

TEST PANEL RA
CLOSET WALL PROJECT
L.D.R.C.



a - 5/8" plywood - Douglas Fir. Plypanel Grade A-D.

b - 4d casing nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: October 1, 1951

Mtls Cost/Sq.Ft.	34.0¢
Weight/Sq.Ft.	1.9#

One specimen was tested in the following sequence:

1. Concentrated Load Test.
2. Uniform Load Test.
3. 15# Impact Test
4. 30# Impact Test
5. 60# Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL RA

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.100	.002
90#	.223	.004

Uniform Load Test

Load	Deflection	Set
5#/sf	.109	-
10	.219	-
15	.328	-
20	.422	-
25	.531	-
30	.625	-
35	.719	-

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.312	.002
12	.437	.006
18	.500	.006
24	.609	.003
30	.672	.006
36	.766	.004
42	.531	.007
48	.797	.011
54	.844	.014

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.094	.007
12	1.391	.008
18	1.594	.007
24	1.812	.011
30	1.937	.007
36	2.047	.013
42	2.172	.018
48	2.234	.026

OBSERVATIONS OF DAMAGE ON PANEL RA

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

No apparent damage.

15# IMPACT TEST

No apparent damage.

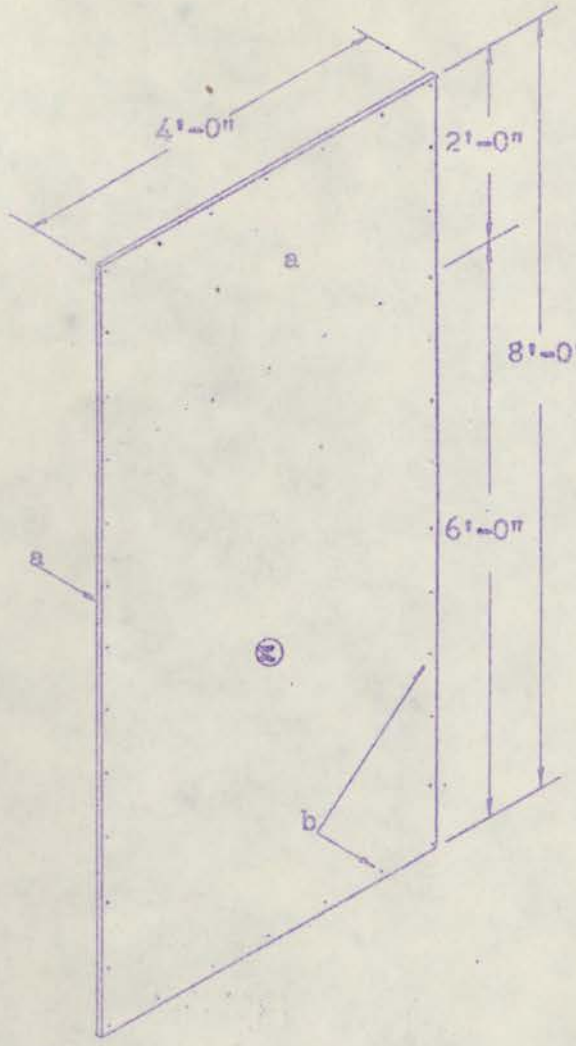
30# IMPACT TEST

HT of Drop	REMARKS
48"	No apparent damage.

1/2" PLYWOOD

1/2" plywood

TEST PANEL RC
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" plywood, Douglas Fir. Plywood panel Grade A-D.

b - 4d casing nails 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: October 10, 1951

Mtls Cost/Sq.Ft. 39¢
1.51#

One specimen was tested in the following sequence:

1. Concentrated Load Test
2. Uniform Load Test
3. 15# Impact Test
4. 30# Impact Test
5. 60# Impact Test

⊼ - Indicates axis of load.
◯ - Indicates axis of deflection and set readings.

TABULATION OF TEST RESULTS PANEL RC

(Only One Specimen Built and Tested)

Concentrated Load Test

Load	Indentation	Set
40#	.167	.003
90#	.327	.015

Uniform Load Test

Load	Deflection	Set
5#/sf	.187	-
10	.344	-
15	.484	-
20	.609	-
25	.719	-
30	.797	-
35	.922	.016

15# Impact Test

Ht. of Drop	Deflection	Set
6"	.469	.001
12	.687	.002
18	.812	.003
24	.937	.011
30	1.000	.005
36	1.062	.010
42	1.141	.003
48	1.234	.014
54	1.250	.006
54	1.469	.018

60# Impact Test

Ht. of Drop	Deflection	Set
6"	1.187	.003
12	1.609	.015
18	1.875	.017
24	2.000	.017
30	2.250	.013
36	2.437	.017
42	2.469	.017
48	2.781	.014
54	3.047	.029
54	3.687	.017

OBSERVATIIONS OF DAMAGE ON PANEL RC

(Only one specimen built and tested)

Specimen No. 1

CONCENTRATED LOAD TEST

No apparent damage.

UNIFORM LOAD TEST

No apparent damage.

60# IMPACT TEST

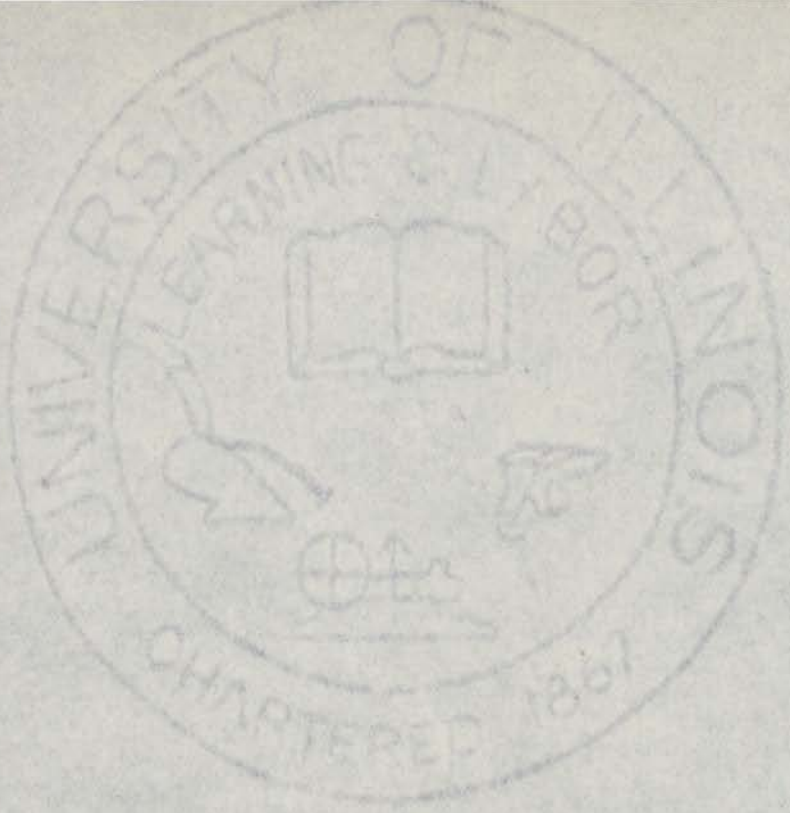
No apparent damage.

15# IMPACT TEST

No apparent damage.

30# IMPACT TEST

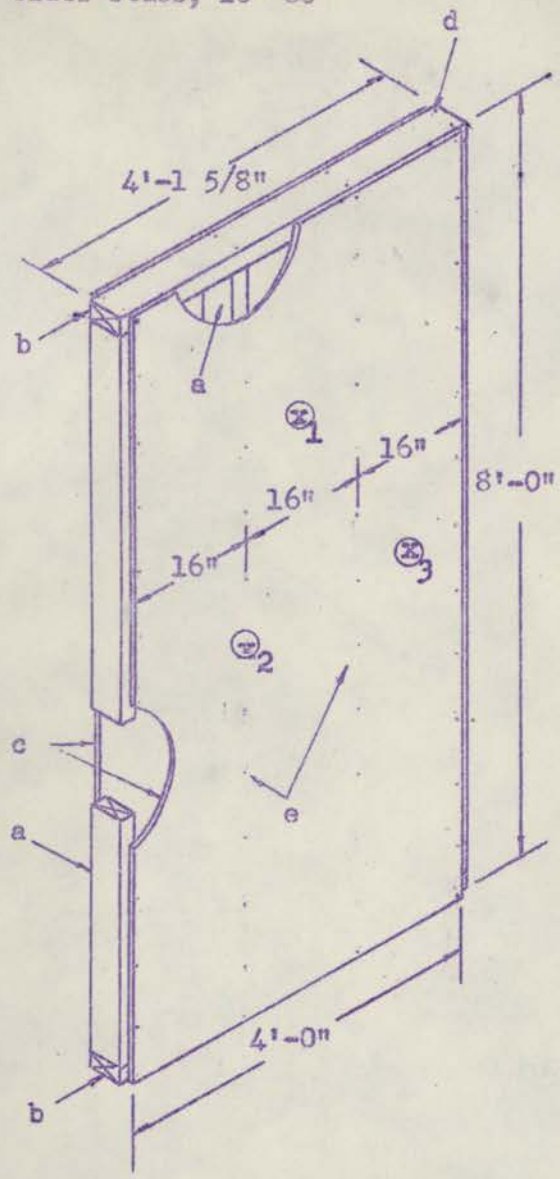
HT of Drop	REMARKS
54"	No apparent damage.



4" STUD WALL

TEST PANEL AX
CLOSET WALL PROJECT
L.D.R.C.

3/8" gypsum board
2 sides studs, 16" oc



a - 4 studs - 16" o. c.
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 3/8" gypsum board 4/0 x 8/0 nailed to both sides of stud frame

d - 16d common nails through top and bottom plate - 2 per junction

e - 4d cement coated nails 8" o. c., 3/8" minimum edge distance

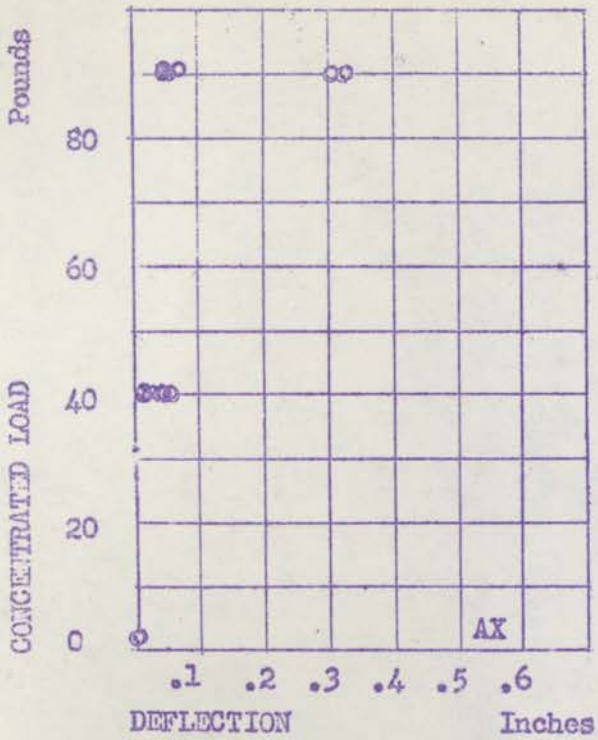
Built: August 13, 1951
Trade Name: U.S. Gypsum
Sheet Rock (c)

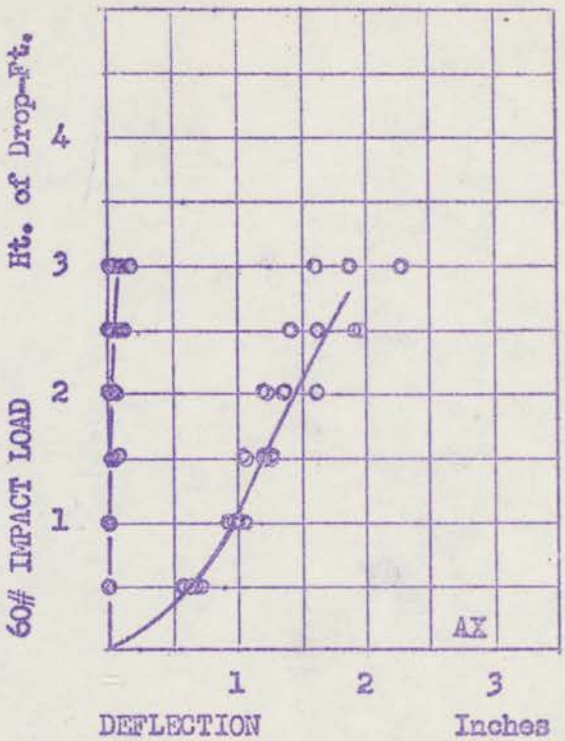
Mtls Cost/Sq.Ft.	26.3¢
Weight/Sq.Ft.	4.87#

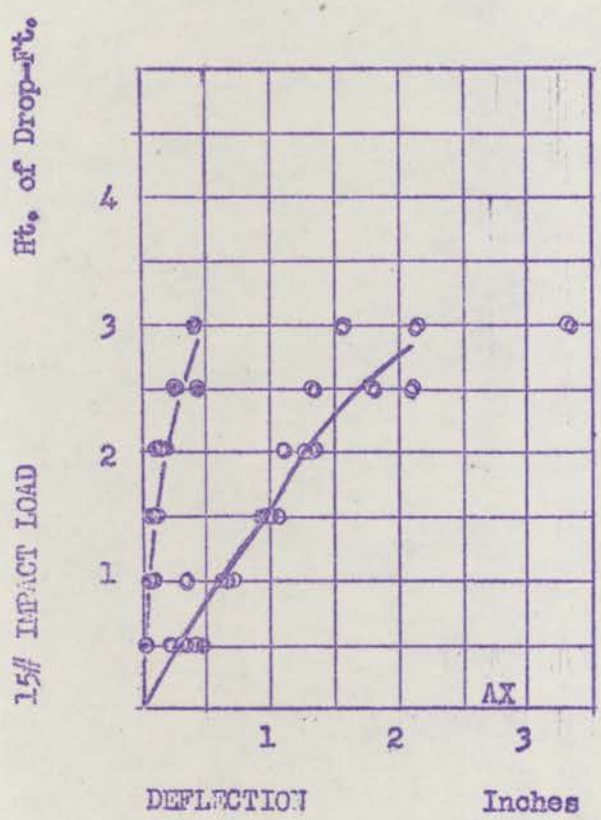
Three specimens were tested in the following sequence:

1. Concentrated Load Test
2. 60" Impact Test
3. 15" Impact Test

x - Indicates axis of load
○ - Indicates axis of deflection and set readings
$\textcircled{x}_1$ - Subscript denotes test number 1







Open circles: deformation under load

Solid circles: Sets after load removed

Continuous line: Load-deformation curve

Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL AX

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.048	.301
2	.063	.326
3	.039	*
Average	.050	.313

Concentrated Load - Set

Specimen 1	.006	.050
2	.009	.054
3	.017	*
Average	.010	.052

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"	42"	48"	54"
Specimen 1	.673	1.156	1.[illegible]19	1.391	1.640	1.890			
2	.610	.906	1.095	1.265	1.431	1.625			
3	.687	.984	1.265	1.640	1.968	2.297			
Average	.657	1.015	1.193	1.432	1.680	1.937			

60# Impact Load Test - Set

Specimen 1	.043	.061	.074	.075	.090	.101
2	.021	.027	.034	.038	.047	.045
3	.014	.022	.059	.091	.130	.187
Average	.026	.036	.055	.068	.089	.111

15# Impact Load Test - Deflection

Specimen 1	.313	.689	.970	1.345	2.125	3.313
2	.203	.359	1.047	1.109	1.329	1.625
3	.420	.720	1.000	1.281	1.800	2.172
Average	.312	.589	1.005	1.245	1.751	2.370

15# Impact Load Test - Set

Specimen 1	.016	.051	.084	.192	.456	Ruptured
2	.025	.064	.102	.135	.270	Ruptured
3	.035	.066	.091	.128	.258	.416
Average	.025	.060	.092	.151	.328	.416

*NOTE: Readings not made because panel was ruptured or failed.

OBSERVATIONS OF DAMAGE ON PANEL AX *

	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST	No apparent damage.	No apparent damage.	Failure under 90# load.

60# IMPACT TEST

HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
24"	Loaded Face: Rupture of wallboard as sand bag bounced off of stud. Unloaded Face: Crack 12" long directly under loaded stud.	36"	Unloaded Face: No apparent damage. Loaded Face: Crack 1' long adjacent to loaded stud.	24"	Loaded Face: Slight crack in wallboard as sand bag bounced off of stud.
30"	Unloaded Face: Above crack increased to 3'.			36"	Loaded Face: Rupture of wallboard (extension of crack listed above). Unloaded Face: Slight cracks directly under loaded stud.
36"	Loaded Face: Crack 3' long adjacent to loaded stud.				

15# IMPACT TEST

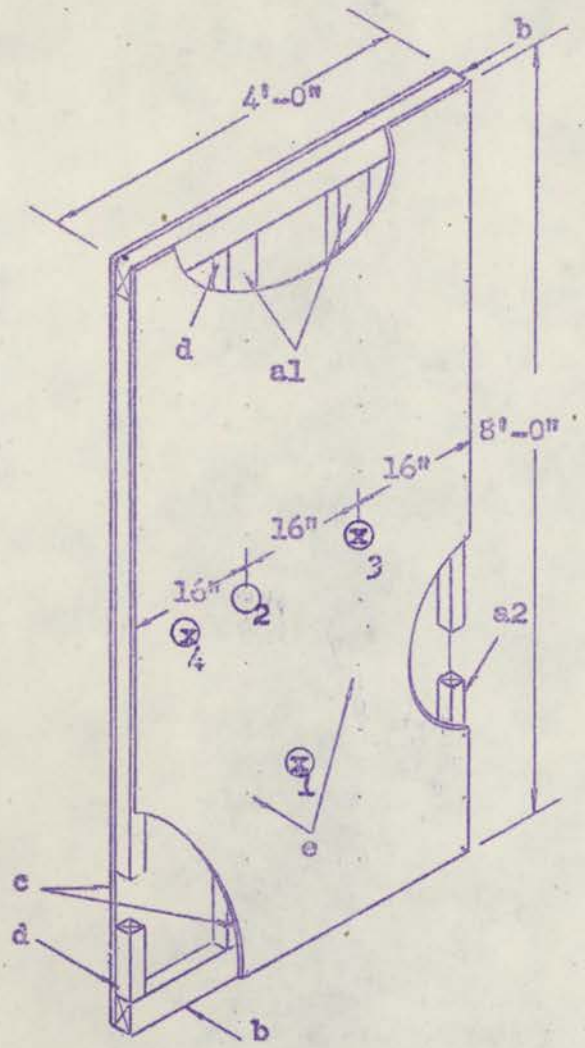
18"	Loaded Face: Crack 8" long adjacent to loaded stud.	18"	Loaded Face: Crack 8" long adjacent to loaded stud.	30"	Loaded Face: Crack 6" long adjacent to stud and crack 14" long directly under load.
24"	Loaded Face: Above crack increased to 13" and a crack 12" long developed directly under load.	24"	Above crack increased to 13".	36"	Crack 6" long increased to 14", 14" crack increased to 22" resulting in rupture of the wallboard.
30"	Both of the above cracks increased 5".	30"	Above crack increased to 15" and a crack 9" long developed directly under load.		
36"	Loaded Face: Definite rupture of wallboard.	36"	Definite rupture of wallboard.		

* Unless otherwise noted cracks listed above were observed in the facing material only.

2" STUD WALL

3/8" gypsum board
2 sides studs, 16" oc

TEST PANEL AT
CLOSET WALL PROJECT
L.D.R.C.



a1 - 2 studs - 16" oc
2 x 4 #2 Douglas Fir

a2 - 2 studs - ripped
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 3/8" Gypsum Board 4/0 x 8/0 nailed to both sides of stud frame.

d - 16d nails toenailed into top and bottom plate. Two per junction. 8d nails at end studs. Two per junction.

e - 4d coated box nails - 8" oc. 1/2" minimum edge distance,

Built: September 10, 19[illegible]
Trade Name: Certain-teed
Bestwall (c)

Mtls Cost/Sq.Ft. 6.3¢
Weight/Sq.Ft. 1.53#

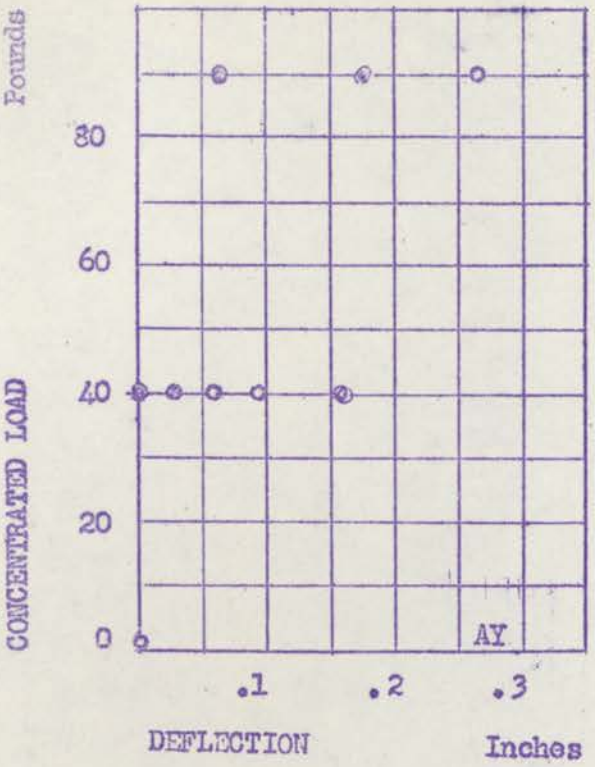
Three specimens were tested in the following sequence:

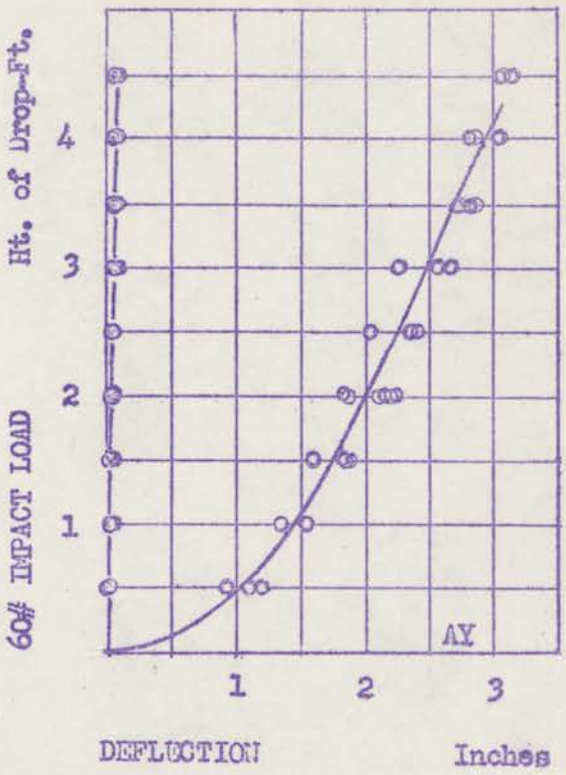
1. Concentrated Load Test
2. Uniform Load Test
3. 60# Impact Test
4. 15# Impact Test *

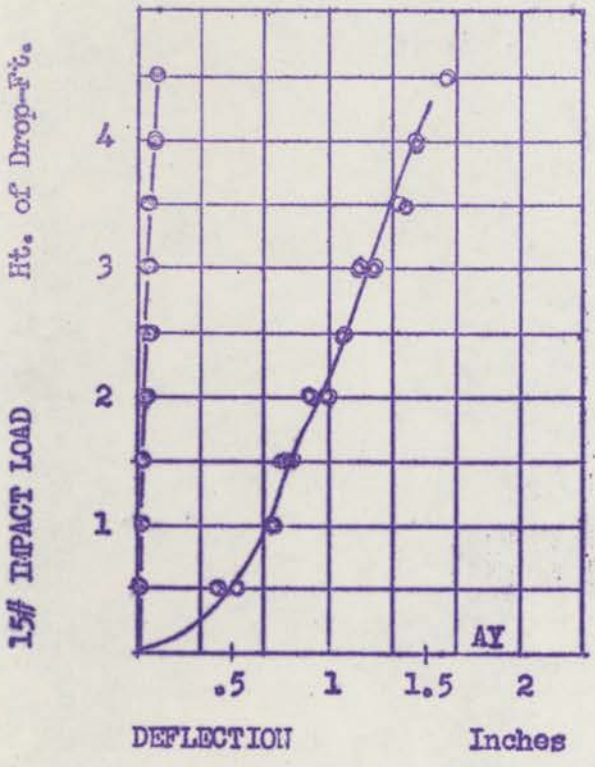
x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.
⊗$_1$ - Subscript denotes number of test.

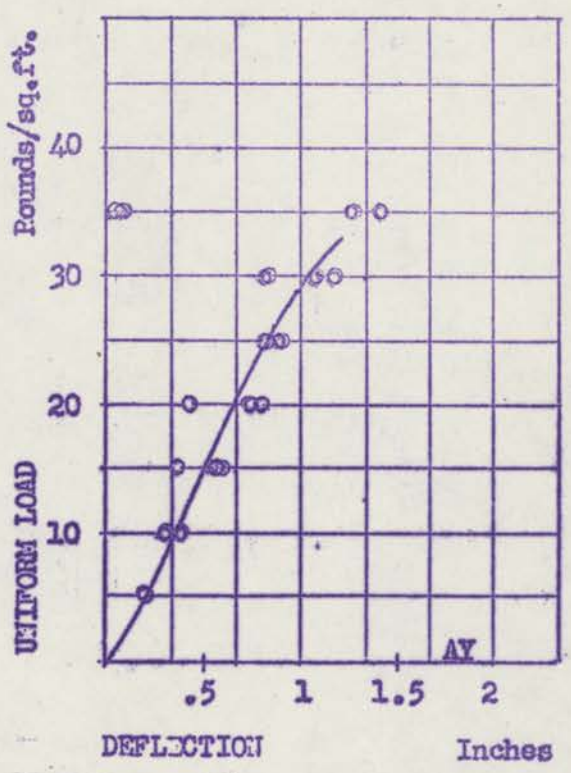
* NOTE: Only two panels received the 15# Impact Test.

GRAPHICAL PRESENTATION OF TEST RESULTS









Open circles: deformation under load

Solid circles: Sets after load removed

Continuous line: Load-deformation curve

Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL AX

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.057	.265
2	.095	*
3	.163	.505
Average	.105	.385

Concentrated Load - Set

Specimen 1	.007	.065
2	.030	*
3	.030	.178
Average	.022	.121

Uniform Load Test - Deflection

Applied Load	5#/sf	10#/sf	15#/sf	20#/sf	25#/sf	30#/sf	35#/sf
Specimen 1	-	.328	.390	.453		.875	-
2	.203	.406	.578	.766	.937	1.141	1.312
3	.203	.406	.609	.828	.859	1.219	1.453
Average	.203	.380	.526	.682	.898	1.078	1.382

Uniform Load Test - Set

Specimen 1	-	-	-	-	-	-	.101
2	-	-	-	-	-	-	.061
3	-	-	-	-	-	-	.075
Average							.079

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"	42"	48"	54"
Specimen 1	.953	1.360	1.609	1.875	2.095	2.296			
2	1.203	1.562	1.859	2.109	2.359	2.562	2.734	2.859	3.094
3	1.125	1.562	1.891	2.219	2.375	2.672	2.875	3.062	3.172
Average	1.094	1.495	1.786	2.068	2.276	2.510	2.805	2.960	3.133

60# Impact Load Test - Set

Specimen 1	.018	.030	.040	.049	.061	.070			
2	.011	.023	.035	.047	.061	.077	.090	.105	.104
3	.012	-	.019	.019	.039	.053	.072	.081	.081
Average	.013	.017	.031	.038	.053	.066	.081	.093	.092

15# Impact Load Test - Deflection

Specimen 2	.422	.719	.781	1.047	1.109	1.187			
3	.562	.719	.828	.922	1.109	1.297	1.391	1.484	1.641
Average	.492	.719	.804	.984	1.109	1.242	1.391	1.484	1.641

15# Impact Load Test - Set

Specimen 2	.014	.038	.049	.075	.088	.107			
3	.012	.013	.032	.051	.061	.065	.078	.117	.121
Average	.013	.025	.040	.063	.074	.086	.078	.117	.121

*NOTE: Readings not made because panel was ruptured or failed.

OBSERVATIONS OF DAMAGE ON PANEL AY *

	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST			
	No apparent damage	Failure under 90# load	No apparent damage
UNIFORM LOAD TEST			
	No apparent damage	No apparent damage	No apparent damage

60# IMPACT TEST

HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
42"	Unloaded Face: Crack 4" long directly under loaded stud.	24"	Unloaded Face: Two cracks 2" long along edge of loaded stud.	36"	Loaded Face: Crack 8" long as sand bag bounced off of stud.
48"	Above crack increased to 1'. Loaded Face: Crack 2" long directly under load.	30"	Above cracks increased to 2'.	54"	Loaded Face: Two cracks 6" long directly under load.
54"	Unloaded Face: Two cracks 1'6" long directly under loaded stud (extension of crack listed above).	36"	Above cracks increased to 4'. Loaded Face: Crack 4" long as sand bag bounced off of stud.		

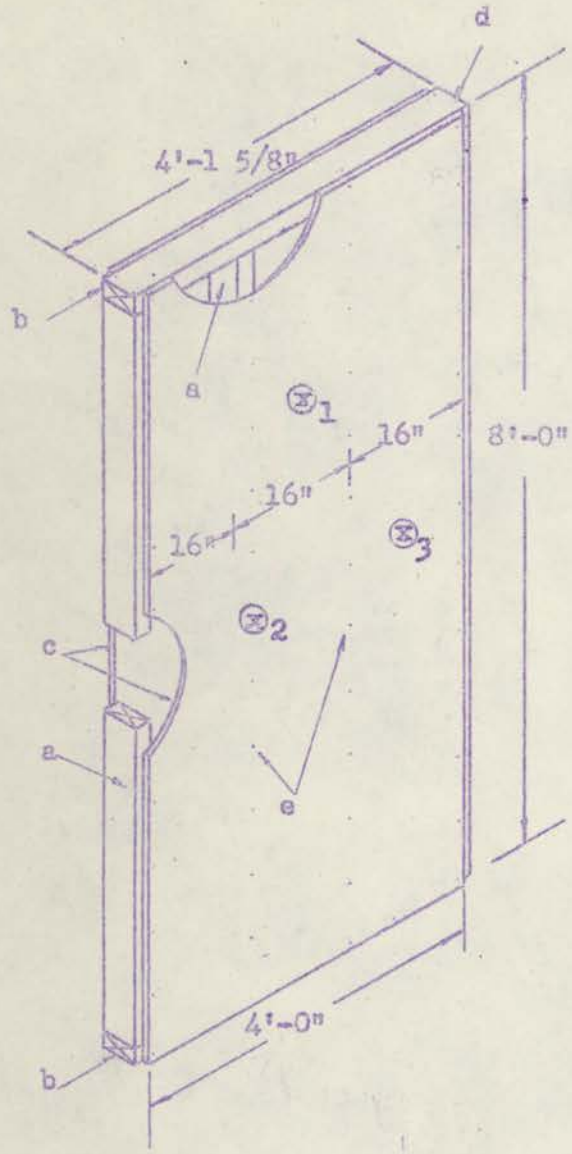
15# IMPACT TEST

24"	Loaded Face: Crack 2" long adjacent to stud.	36"	Loaded Face: Crack 1" long adjacent to stud.	Not tested
30"	Above crack increased to 6".	42"	Above crack increased to 5".	
36"	Above crack increased to 1' resulting in a definite rupture of the wallboard.			
		54"	Above crack extended to 16".	

* Unless otherwise noted cracks listed above were observed in the facing material only.

STUD WALL
1/2" fiberboard
2 sides studs, 16" oc

TEST PANEL BY
CLOSET WALL PROJECT
L.D.R.C.



a - 4 studs - 16" o. c.
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 1/2" fiberboard 4/0 x 8/0 nailed to both sides of stud frame

d - 16d common nails through top and bottom plate - 2 per junction

e - 4d cement coated nails 8" o. c., 3/8" minimum edge distance

Built: August 20, 1951
Trade Name: Celotex Corporation (c)

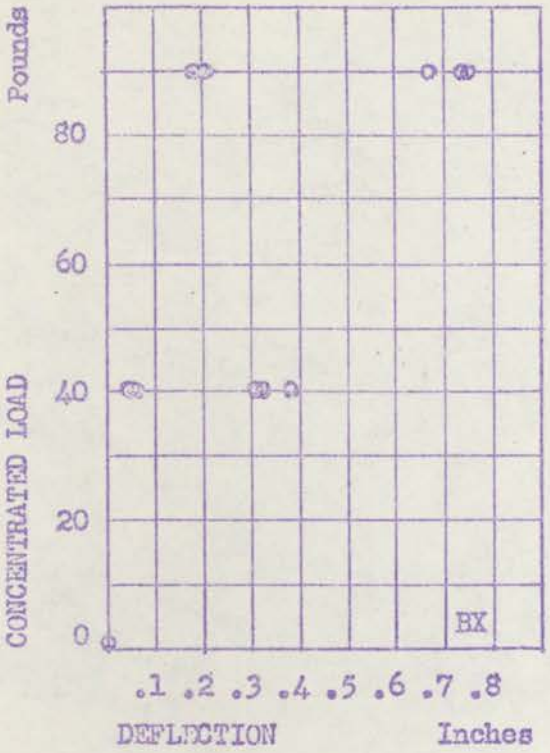
Mtls Cost/Sq.Ft.	28.3¢
Weight/Sq.Ft.	3.37#

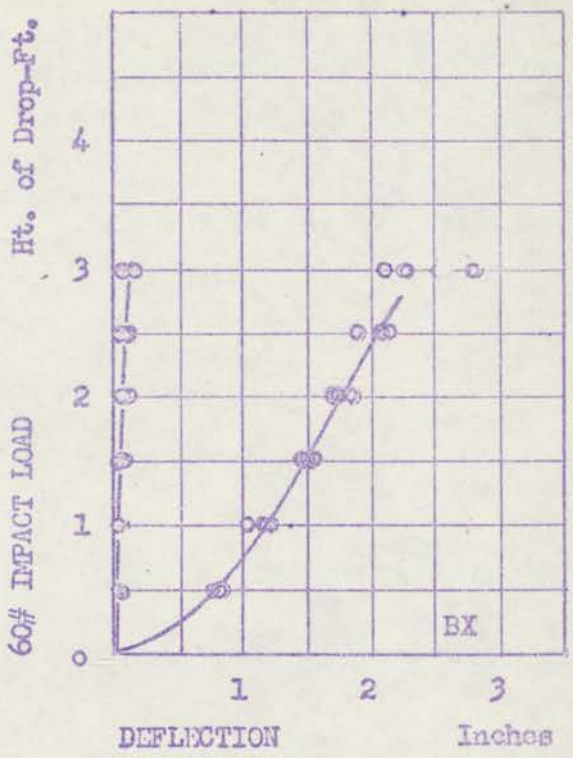
Three specimens were tested in the following sequence:

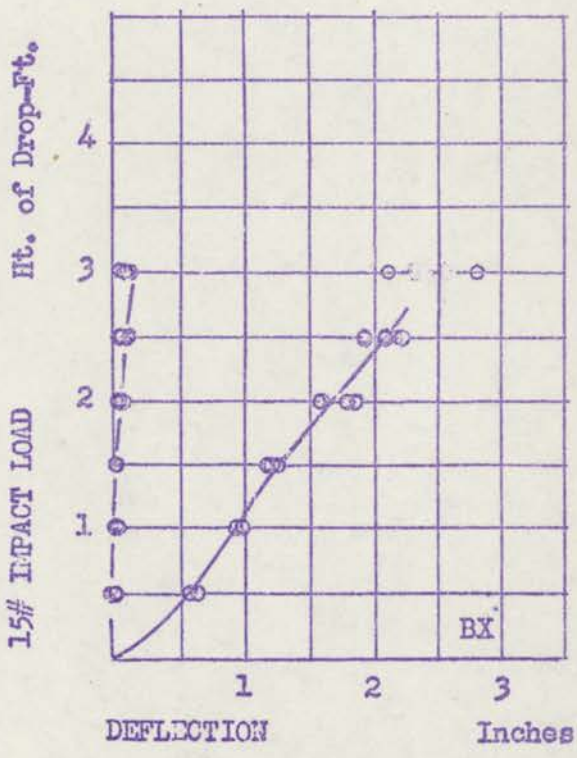
1. Concentrated Load Test
2. 60# Impact Test
3. 15# Impact Test

⊗ - Indicates axis of load.
○ - Indicates axis of deflection and set readings.
⊗1 - Subscript denotes test number.

GRAPHICAL PRESENTATION OF TEST RESULTS







Open Circles: deformation under load

Solid circles: Set after load removed

Continuous line: Load-deformation curve

Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL BX

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.324	.742
2	.387	.764
3	.313	.673
Average	.341	.726

Concentrated Load - Set

Specimen 1	.046	.187
2	.061	.210
3	.052	.181
Average	.053	.192

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"
Specimen 1	.855	1.047	1.525	1.890	2.156	2.260
2	.828	1.203	1.484	1.766	2.109	2.828
3	.844	1.219	1.500	1.719	1.906	2.094
Average	.842	1.156	1.503	1.792	2.057	2.394

60# Impact Load Test - Set

Specimen 1	.036	.046	.038	.108	.108	.108
2	.035	.040	.043	.054	.135	.170
3	.045	.059	.058	.059	.063	.068
Average	.038	.483	.063	.073	.102	.115

15# Impact Load Test - Deflection

Specimen 1	.625	.953	1.203	1.656	2.344	2.094
2	.672	1.000	1.219	1.813	1.984	2.375
3	.688	1.000	1.344	1.828	2.359	2.391
Average	.661	.984	1.255	1.765	2.229	2.286

15# Impact Load Test - Set

Specimen 1	.052	.073	.093	.107	.172	.217
2	.032	.067	.091	.142	.192	.246
3	.040	.055	.083	.118	.190	.226
Average	.041	.065	.089	.122	.160	.229

OBSERVATIONS OF DAMAGE ON PANEL BX *

	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST	No apparent damage.	Under 90# fibers separated slightly.	No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
36"	No apparent damage	36"	No apparent damage	36"	No apparent damage.

15# IMPACT TEST

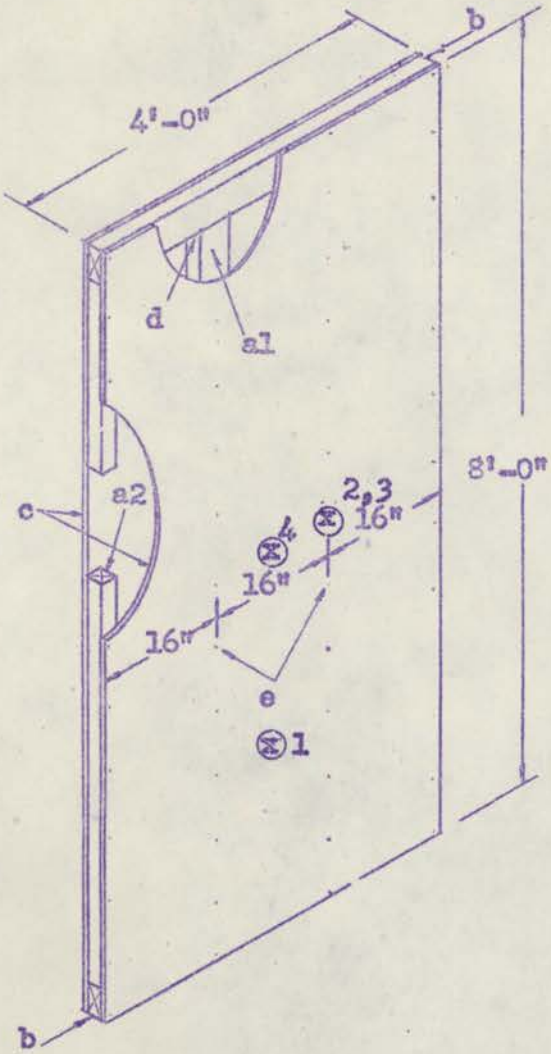
30"	Loaded Face: Crack 6" long adjacent to loaded stud.	36"	Above crack increased to 8".	24"	Loaded Face: Slight cracks ½" long adjacent to loaded stud.
36"	Above crack increased to 1' and fiber board pulled slightly at adjacent nails.	24"	Loaded Face: Fiber board pulled slightly at adjacent nails.	30"	Above cracks extended forming one crack 12" long.
		30"	Loaded Face: Crack 6" long adjacent to loaded stud.	36"	Above crack increased and a crack 12" long developed directly under load. Fiber board also pulled at adjacent nails.

* Unless otherwise noted cracks listed above were observed in the facing material only.

2" STUD WALL

1/2" fiberboard
2 sides studs, 16" oc

TEST PANEL BY
CLOSET WALL PROJECT
L.D.B.C.



a1 - 2 studs - 16" oc
2 x 4 #2 Douglas Fir

a2 - 2 studs - ripped
2 x 4 #2 Douglas Fir

b - Top and bottom plate
2 x 4 #2 Douglas Fir

c - 1/2" fiberboard 4/0 x 8/0 nailed to both sides of stud frame.

d - 16d nails toenailed into top and bottom plate. Two per junction. 8d nails for end studs.

e - 4d coated box nails - 8" oc. 1/2" minimum edge distance,

Built: September 10, 1951
Trade Name: Celotex (c)

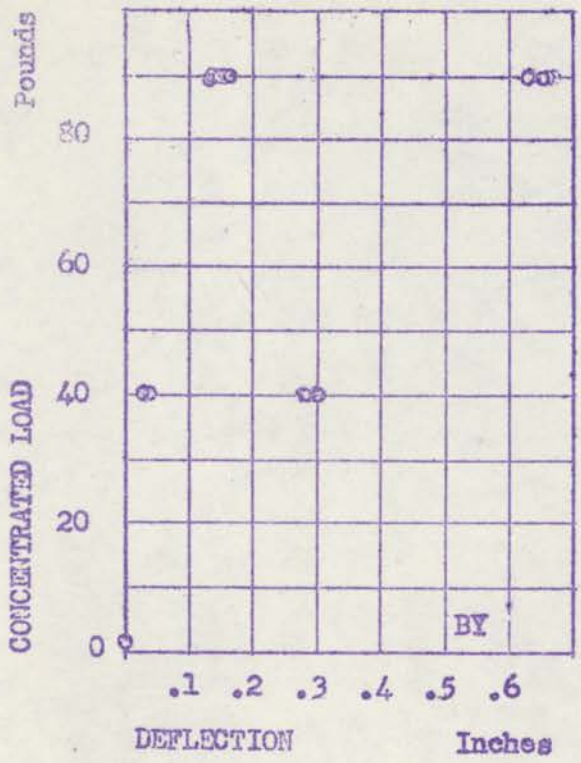
Mtls Cost/Sq.Ft.	28.3¢
Weight/Sq.Ft.	3#

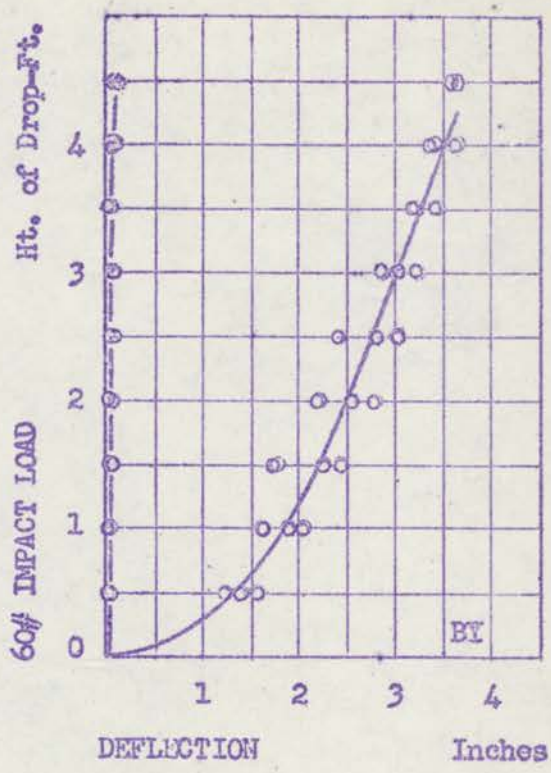
Three specimens were tested in the following sequence:

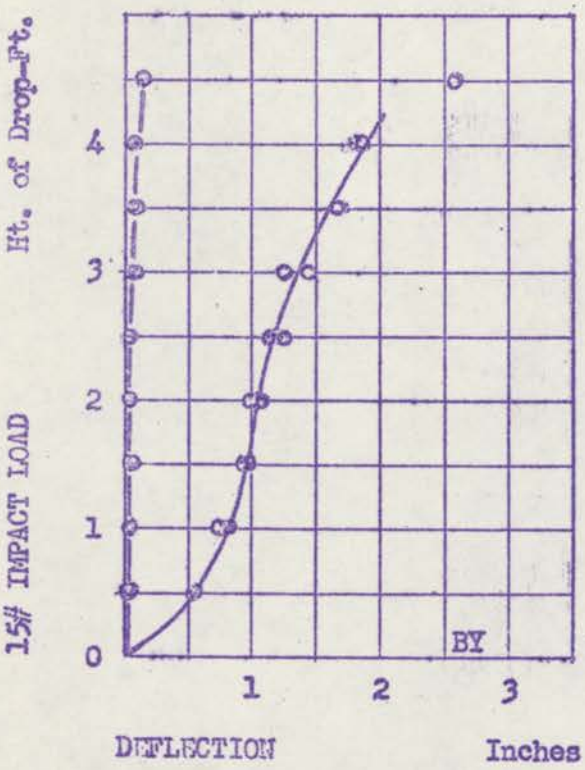
1. Concentrated Load Test
2. Uniform Load Test
3. 60# Impact Test
4. 15' Impact Test

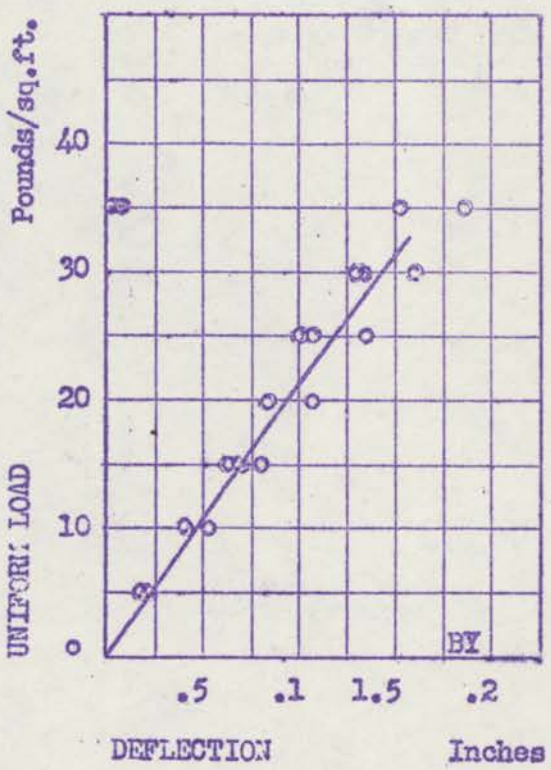
x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.
$\otimes_1$ - Subscript denotes test number.

GRAPHICAL PRESENTATION OF TEST RESULTS









Open circles: deformation under load
Solid circles: Sets after load removed

Continuous line: Load-deformation curve
Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL BY

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.282	.634
2	.300	.668
3	.289	.667
Average	.290	.656

Concentrated Load - Set

Specimen 1	.045	.157
2	.041	.161
3	.035	.143
Average	.040	.153

Uniform Load Test - Deflection

Applied Load	5#/sf	10#/sf	15#/sf	20#/sf	25#/sf	30#/sf	35#/sf
Specimen 1	-	.563	.703	-	1.016	1.313	-
2	.234	.531	.812	1.094	1.359	1.625	1.891
3	.187	.422	.641	.859	1.094	1.312	1.516
Average	.210	.505	.719	.976	1.156	1.417	1.703

Uniform Load Test - Set

Specimen 1	-	-	-	-	-	-	.108
2	-	-	-	-	-	-	.111
3	-	-	-	-	-	-	.067
Average	-	-	-	-	-	-	.095

60# Impact Load Test - Deflection

	6"	12"	18"	24"	30"	36"	42"	48"	54"
Specimen 1	1.265	1.640	1.703	2.218	2.421	2.796			
2	1.594	2.109	2.453	2.734	3.016	3.250			
3	1.422	1.922	2.297	2.594	2.812	3.016			
Average	1.427	1.890	2.151	2.515	2.750	3.026			

60# Impact Load Test - Set

Specimen 1	.024	.034	.034	.043	.052	.059
2	.019	.013	.010	.021	.032	.033
3	.007	.010	.018	.022	.033	.037
Average	.016	.019	.020	.028	.039	.043

15# Impact Load Test - Deflection

Specimen 2	.547	.766	.969	1.000	1.187	1.453	1.734	1.891	*
3	.547	.750	.953	1.016	1.266	1.375	1.766	1.875	2.641
Average	.547	.758	.961	1.008	1.226	1.414	1.750	1.883	2.641

15# Impact Load Test - Set

Specimen 2	.013	.037	.035	.048	.055	.069	.146	*	*
3	.023	.040	.035	.040	.056	.075	.072	.083	.145
Average	.018	.038	.035	.044	.055	.072	.109	.083	.145

*NOTE: Readings not made because panel was ruptured or failed.

OBSERVATIONS OF DAMAGE OF PANEL BY *

	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST	No apparent damage.	No apparent damage.	No apparent damage.
UNIFORM LOAD TEST	No apparent damage.	No apparent damage.	No apparent damage.

60# IMPACT TEST

HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
36"	No apparent damage.	54"	Loaded Face: Crack 4" long perpendicular to loaded stud.	54"	No apparent damage.

15# IMPACT TEST

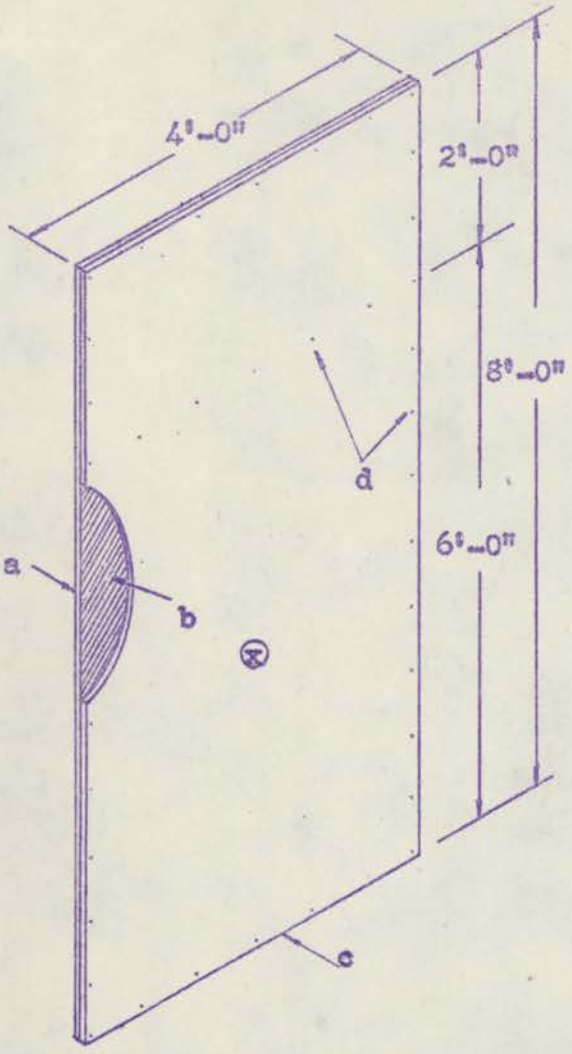
Not tested.		42"	Loaded Face:Crack 6" long directly under load.	48"	Loaded Face: Crack 6" long adjacent to loaded stud.
		48"	Above crack increased to 12" resulting in rupture of fiber board.		

* Unless otherwise noted cracks listed above were observed in the facing material only.

1" DOUBLE LAMINATE

1/2" gypsum board
with wallboard cement

TEST PANEL F
CLOSET WALL PROJECT
L.D.R.C.



a - 1/2" gypsum board 4/0 x 8/0

b - Wallboard cement - 3 lbs/ panel spread with a "V" notched trowel.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a".

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

d - 6d box nails - 8" oc. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: September 10, 1951
Trade Name: U. S. Gypsum Co. Sheetrock (a) & (c)

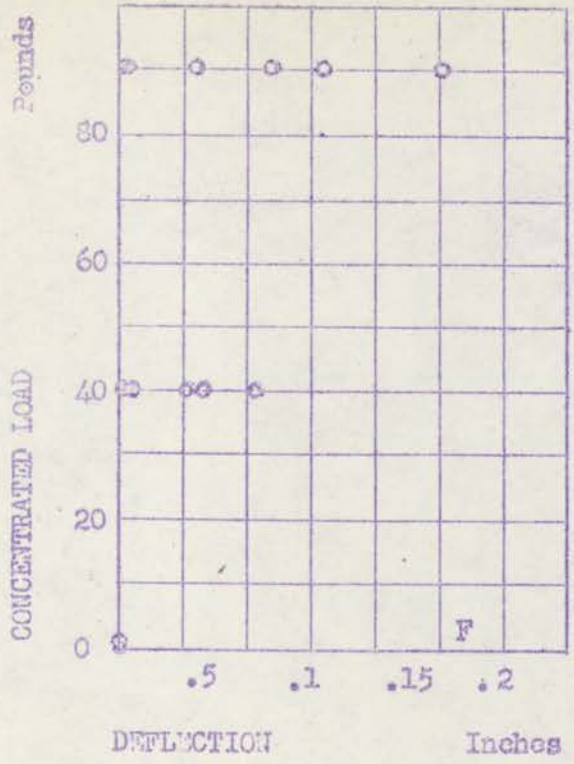
Perf-A-Tape Cement by U. S. Gypsum Co. (b)

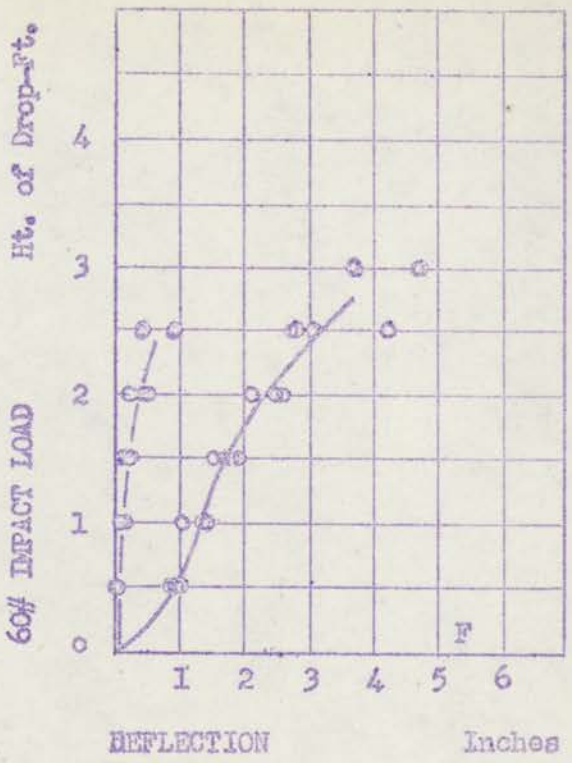
Mtls Cost/Sq.Ft.	16.6¢
Weight/Sq.Ft.	4.5#

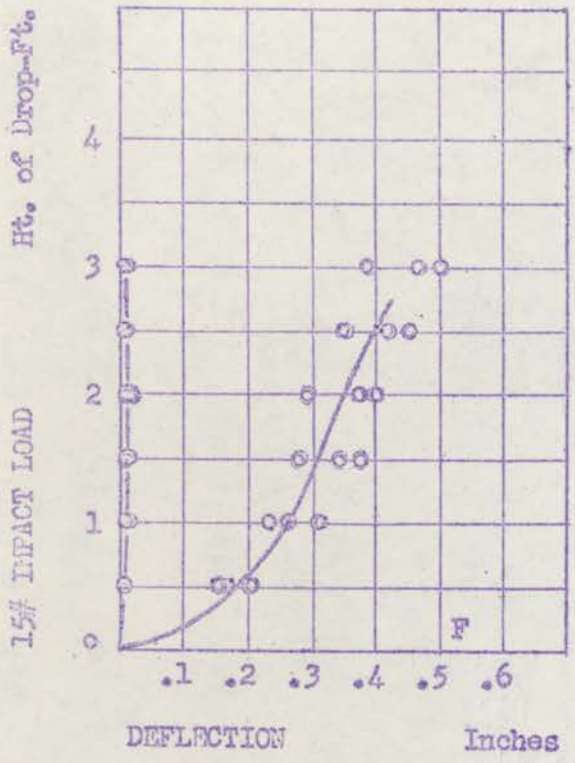
Three specimens were tested in the following sequence:

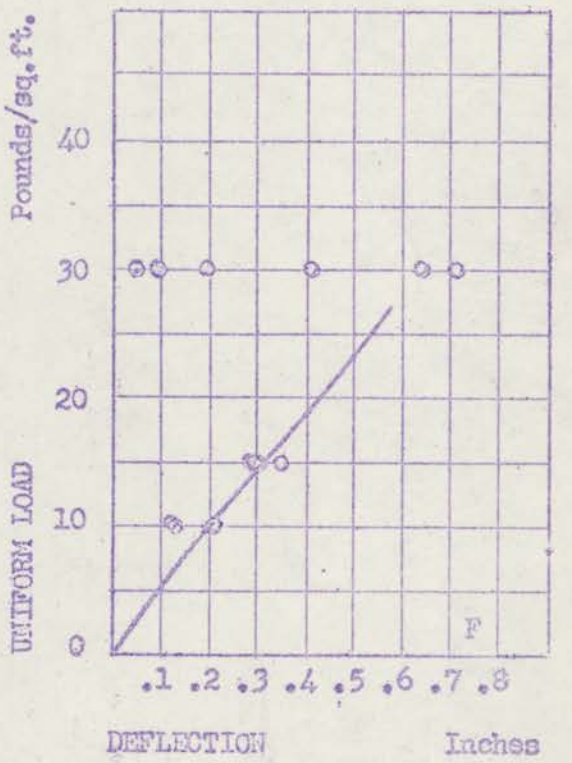
1. Concentrated Load Test
2. 15# Impact Test
3. Uniform Load Test
4. 60" Impact Test

x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.









Open circles: deformation under load
Solid circles: Sets after load removed

Continuous line: Load-deformation curve
Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL F

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.047	.105
2	.072	.169
3	.038	.080
Average	.052	.118

Concentrated Load - Set

Specimen 1	.004	.005
2	.005	.040
3	.001	.004
Average	.003	.016

Uniform Load Test - Deflection

Applied Load	10.5#/sf	15.5#/sf	30#/sf
Specimen 1	.203	.296	.718
2	.203	.297	.641
3	.133	.351	.414
Average	.180	.315	.591

Uniform Load Test - Set

Specimen 1	-	-	.198
2	-	-	.096
3	-	-	.055
Average	-	-	.116

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"
Specimen 1	.921	1.390	1.796	2.562	4.265	*
2	.984	1.484	1.953	2.547	3.062	4.750
3	.813	1.187	1.586	2.156	2.843	3.796
Average	.906	1.354	1.778	2.422	3.390	4.273

60# Impact Load Test - Set

Specimen 1	.046	.112	.231	.697	*	*
2	.046	.108	.211	.482	.938	*
3	.038	.078	.147	.249	.430	*
Average	.043	.0999	.196	.476	.684	*

15# Impact Load Test - Deflection

Specimen 2	.171	.265	.344	.375	.421	.469
3	.203	.312	.375	.390	.453	.500
4	.156	.234	.281	.297	.359	.390
Average	.176	.270	.333	.354	.411	.453

15# Impact Load Test - Set

Specimen 1	.003	.015	.003	.004	.005	.007
2	.000	.003	.002	.003	.003	.005
3	.007	.006	.013	.010	.010	.011
Average	.003	.008	.006	.005	.006	.007

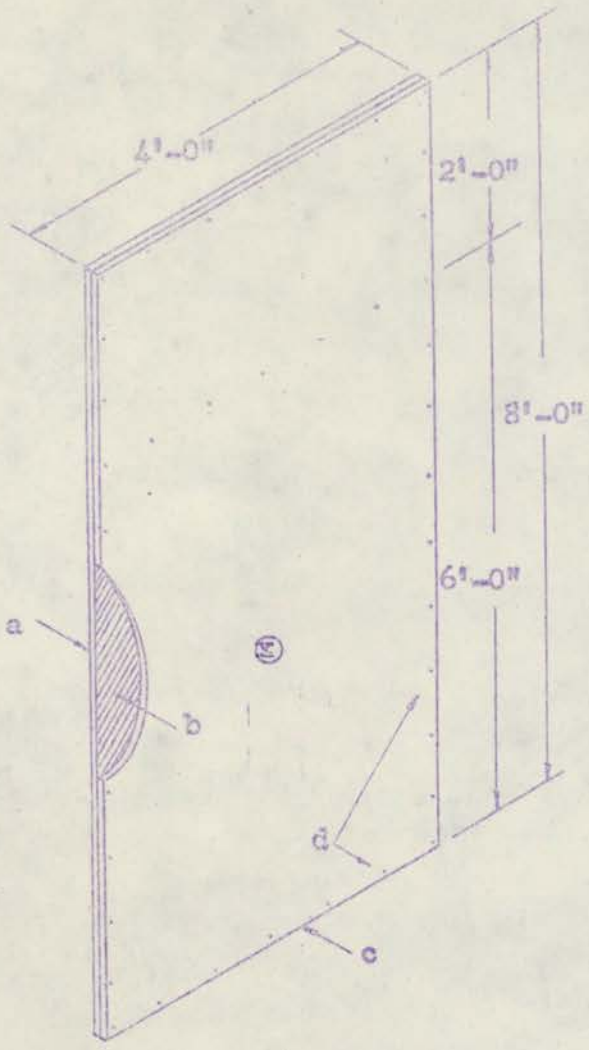
*NOTE: Readings not made because panel was ruptured or failed.

OBSERVATIONS OF DAMAGE ON PANEL F

	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST			
	No apparent damage.	No apparent damage.	No apparent damage.
UNIFORM LOAD TEST			
	No apparent damage.	No apparent damage.	No apparent damage.
60# IMPACT TEST			
HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
18"	Unloaded Face: Two cracks 6" long directly under load.	12"	Unloaded Face: Crack 3" long directly under load.	12"	Unloaded Face: Crease 6" long in paper.
24"	Unloaded Face: Crack 2' long (extension of cracks listed above).	18"	Above crack increased to 1' 6" ("Y" shaped).	18"	Above crease developed into crack 24" long. Loaded Face: Crack 4" long directly under load.
30"	Definite rupture of panel.	24"	Above crack increased to 2'. Loaded Face: Crack 10" long directly under load.	24"	Unloaded Face: Crack 36" long, branch cracks 6" long ("Y" shaped). Loaded Face: Crack 30" long.
		30"	Slight rupture of panel.	30"	Unloaded Face: Crack 5' long with branch cracks 12" long. ("Y" shaped). Loaded Face: Crack 54" long.
				36"	Slight rupture of panel.
15# IMPACT TEST					
36"	No apparent damage.	36"	No apparent damage.	36"	No apparent damage.

3/4" DOUBLE LAMINATE
Double 3/8" gypsum board
with linoleum paste

TEST PANEL FCA
CLOSET WALL PROJECT
L.D.R.C.



a - 3/8" gypsum board 4/0 x 8/0

b - Linoleum paste - 1 1/2 quarts /panel applied with a notched asphalt tile spreader.

c - 3/8" gypsum board 4/0 x 8/0

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

d - 6d box nails - 8" oc. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: October 30, 1951
Trade Name: U. S. G. Sheetrock (a) & (c).
Wolverine Linoleum Paste (b).

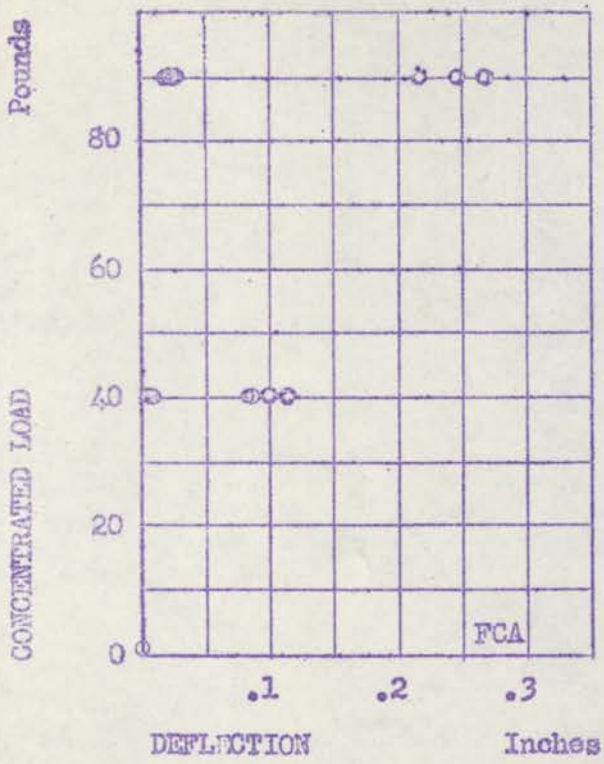
Mtls Cost/Sq.Ft.	14.6¢
Weight/Sq.Ft.	3.12#

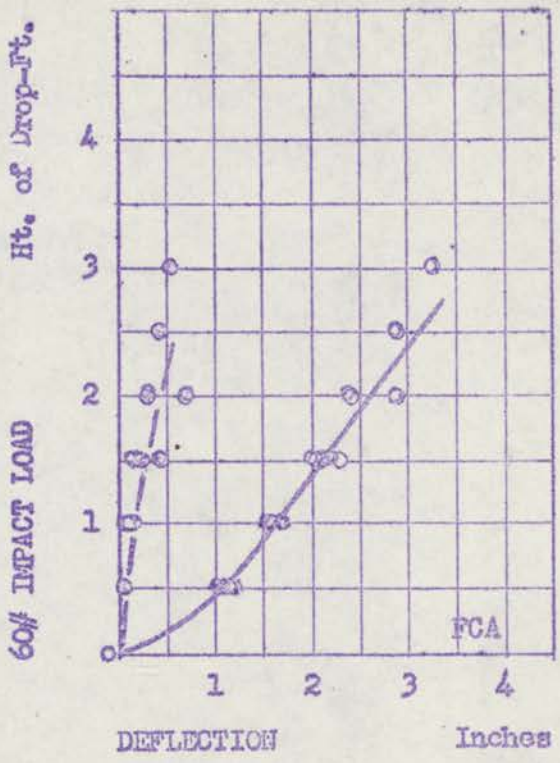
One specimen was tested in the following sequence:

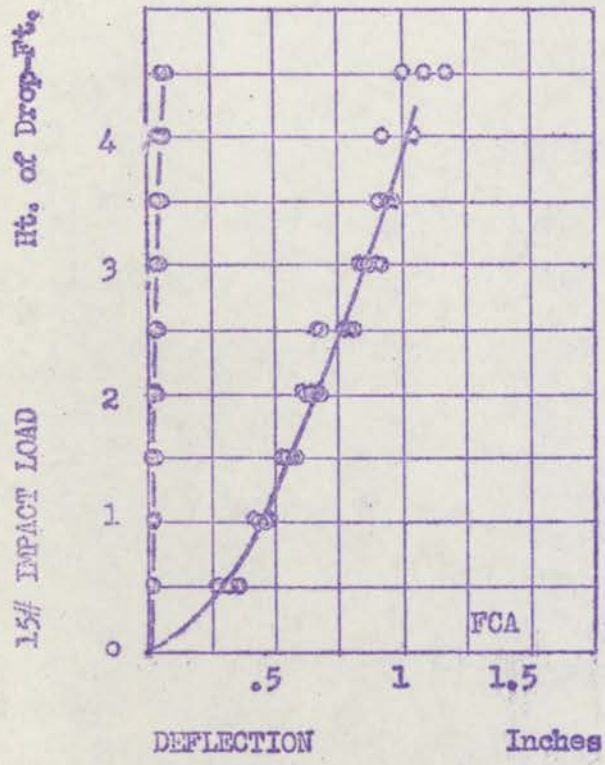
1. Concentrated Load Test
2. Uniform Load Test
3. 15# Impact Test
4. 60# Impact Test

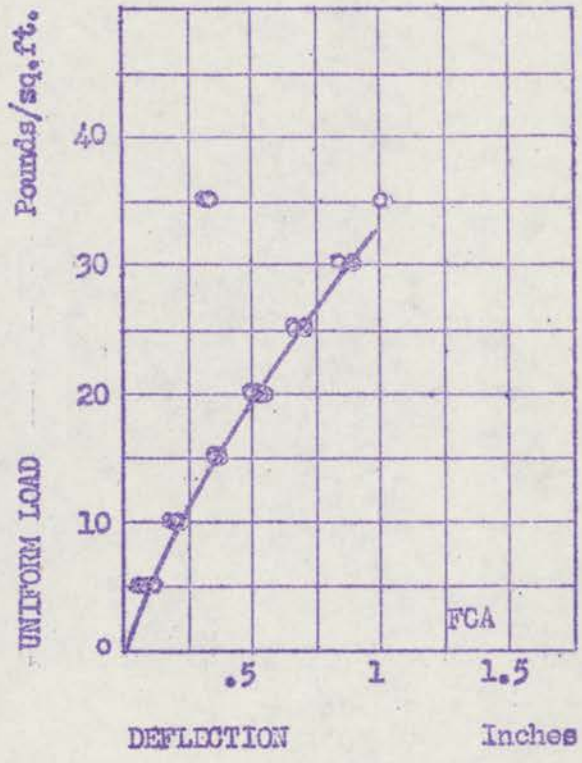
⊠ - Indicates axis of load.
◯ - Indicates axis of deflection and set readings.

GRAPHICAL PRESENTATION OF TEST RESULTS









Open circles: deformation under load
Solid circles: Sets after load removed

Continuous line: Load-deformation curve
Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL FCA

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.089	.218
2	.116	.268
3	.100	.248
Average	.102	.245

Concentrated Load - Set

Specimen 1	- .005	.026
2	.009	.029
3	.006	.020
Average	.006	.025

Uniform Load Test - Deflection

Applied Load	5#/sf	10#/sf	15#/sf	20#/sf	25#/sf	30#/sf	35#/sf
Specimen 1	.094	.234	.375	.547	.719	.906	1.062
2	.125	.234	.359	.531	.719	.906	1.078
3	.062	.203	.359	.500	.672	.844	
Average	.094	.224	.364	.526	.703	.885	1.070

Uniform Load Test - Set

Specimen 1	-	-	-	-	-	-	.327
2	-	-	-	-	-	-	.321
3	-	-	-	-	-	-	.279
Average	-	-	-	-	-	-	.309

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"	42"	48"	52"
Specimen 1	1.203	1.703	2.312	2.906	*	*			
2	1.141	1.609	2.047	2.406	2.906	3.297			
3	1.156	1.562	2.125	*	*	*			
Average	1.167	1.625	2.161	2.656	2.906	3.297			

60# Impact Load Test - Set

Specimen 1	.038	.134	.277	.703	*	*			
2	.042	.116	.183	.306	.428	.535			
3	.047	.113	.422	*	*	*			
Average	.042	.121	.294	.504	.428	.535			

15# Impact Load Test - Deflection

Specimen 1	.375	.484	.594	.687	.812	.922	.969	1.047	1.172
2	.312	.437	.531	.625	.781	.875	.953	1.047	1.094
3	.281	.437	.547	.641	.687	.844	.906	.922	1.000
Average	.322	.452	.557	.651	.760	.880	.942	1.005	1.008

15# Impact Load Test - Set

Specimen 1	.015	.015	.015	.018	.030	.040	.048	.047	.067
2	.015	.016	.007	.012	.030	.028	.033	.046	.072
3	.003	.005	.015	.027	.029	.039	.051	.058	.064
Average	.011	.012	.012	.019	.029	.035	.044	.050	.067

*NOTE: Readings not made because panel was ruptured or failed.

OBSERVATIONS OF DAMAGE ON PANEL FCA

Specimen No. 1	Specimen No. 2	Specimen No. 3

CONCENTRATED LOAD TEST

Specimen No. 1	Specimen No. 2	Specimen No. 3
No apparent damage.	No apparent damage.	No apparent damage.

UNIFORM LOAD TEST

Specimen No. 1	Specimen No. 2	Specimen No. 3
No apparent damage.	No apparent damage.	No apparent damage.

60# IMPACT TEST

Specimen No. 1		Specimen No. 2		Specimen No. 3	
HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
1'	Unloaded Face: Crack 12" long directly under load ("Y" shaped).	24"	Unloaded Face: Crack 8" long directly under load parallel to the short span.	1"	Unloaded Face: Semi circular crack 10" long directly under load.
18"	Above crack increased to 16".	30"	Above crack increased slightly and crack 4" long developed parallel to long span.	18"	Above crack extended to 12" radiating out to the corners of the panel. Loaded Face: Crack 15" long directly under load.
24"	Loaded Face: Curved crack 16" long directly under load with branches 8" long ("Y" shaped). Unloaded Face: Cracks increased resulting in ½" rupture of panel.	36"	Above cracks increased 6".		

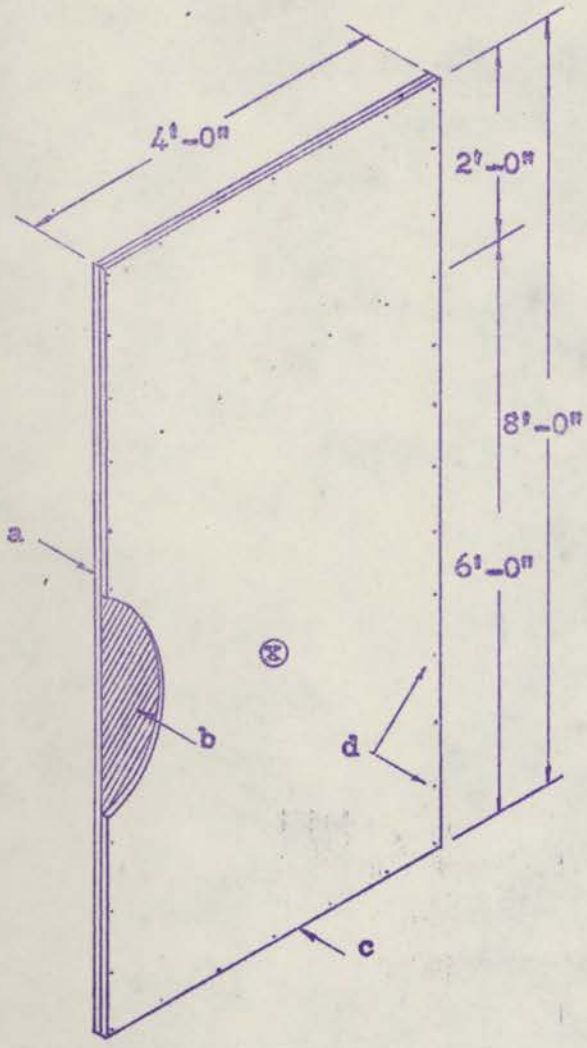
15# IMPACT TEST

54"	No apparent damage.	54"	No apparent damage.	54"	No apparent damage.

5/8" THIN WALL

1/8" tempered hardboard
and 1/2" gypsum board

TEST PANEL OAA
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" tempered hardboard 4/0 x 8/0

b - Linoleum paste - 2 quarts/panel applied with a notched asphalt tile spreader.

c - 1/2" gypsum board 4/0 x 8/0 laminated to "a".

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

d - 6d coated box nails - 8" oc. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: October 9, 1951
Trade Name: U. S. G. Sheetrock (a) & (c)
Wolverine Linoleum Paste (b)

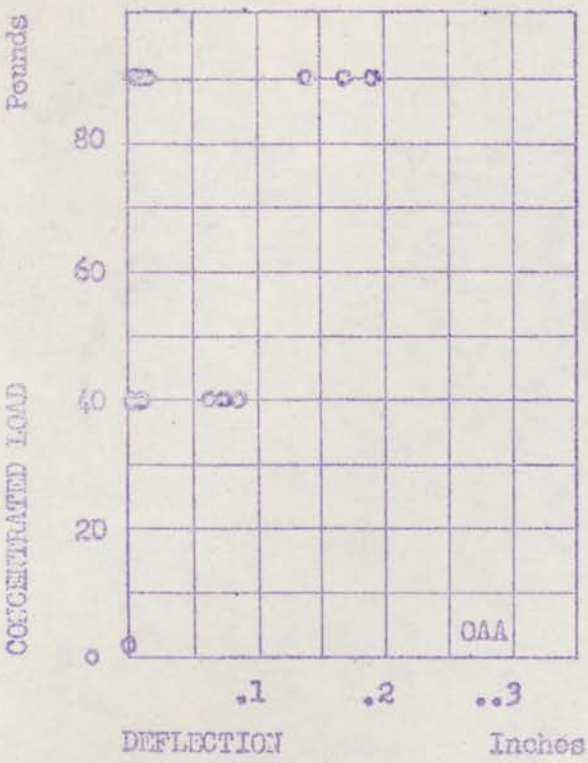
Mtls Cost/Sq.Ft. 20.7¢
Weight/Sq.Ft. 3#

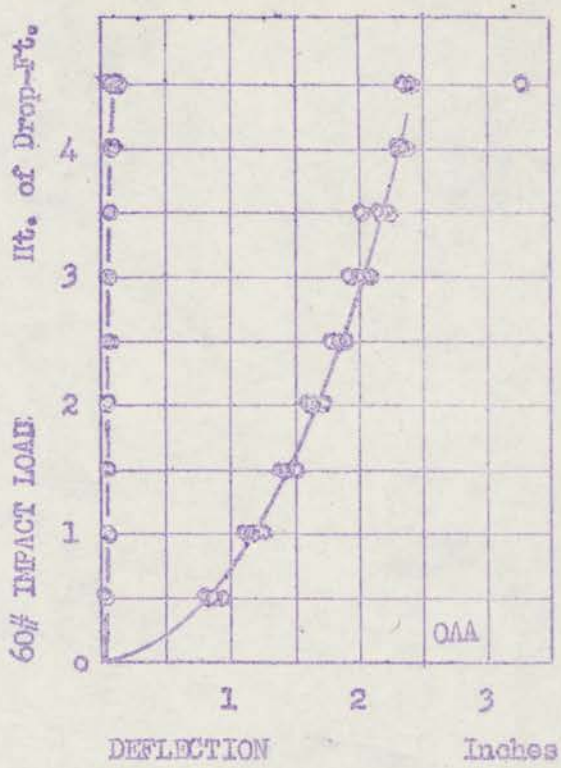
One specimen was tested in the following sequence:

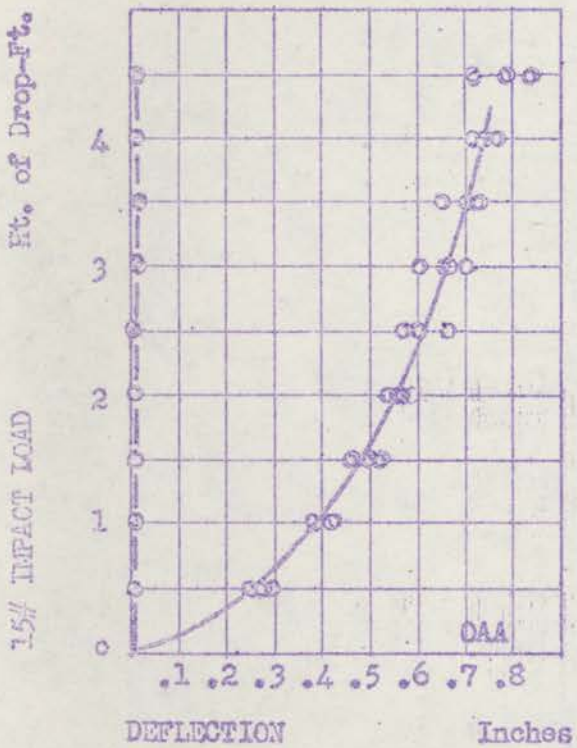
1. Concentrated Load Test
2. Uniform Load Test
3. 15# Impact on Gypsum Board Side.
4. 60# Impact Test on Gypsum Board Side.
5. 15# Impact Test on Hardboard Side.
6. 60# Impact Test on Hardboard Side.

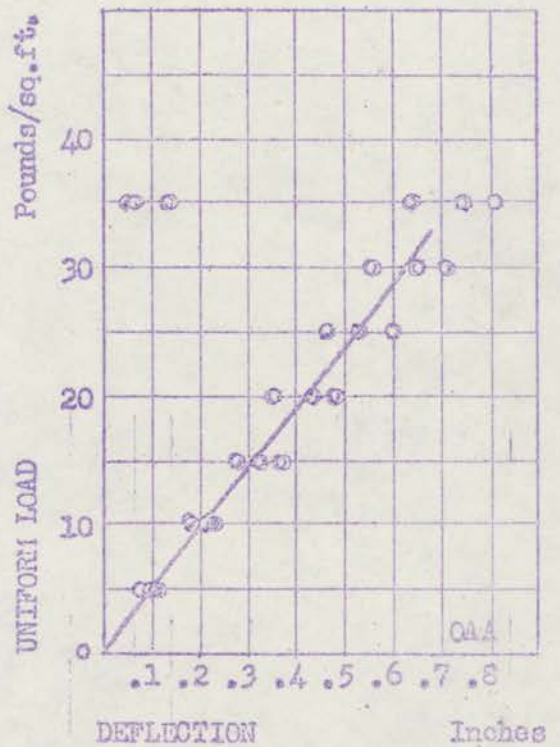
x - Indicates axis of load.
○ - Indicates axis of deflection and set readings.

GRAPHICAL PRESENTATION OF TEST RESULTS









Open circles: deformation under load

Solid circles: Sets after load removed

Continuous line: Load-deformation curve

Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL OAA

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.090	.193
2	.076	.170
3	.064	.141
Average	.077	.168

Concentrated Load - Set

Specimen 1	.011	.019
2	.005	.011
3	.001	.005
Average	.005	.011

Uniform Load Test - Deflection

Applied Load	5#/sf	10#/sf	15#/sf	20#/sf	25#/sf	30#/sf	35#/sf
Specimen 1	.094	.234	.375	.484	.609	.719	.812
2	.109	.219	.328	.437	.531	.656	.750
3	.078	.187	.281	.359	.469	.562	.641
Average	.094	.213	.328	.427	.536	.646	.734

Uniform Load Test - Set

Specimen 1	-	-	-	-	-	-	.147
2	-	-	-	-	-	-	.079
3	-	-	-	-	-	-	.055
Average	-	-	-	-	-	-	.093

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"	42"	48"	52"
Specimen 1	.812	1.187	1.422	1.656	1.859	2.062	2.187	2.328	2.422
2	.937	1.281	1.547	1.719	1.906	2.094	2.250	2.375	3.297
3	.875	1.219	1.422	1.625	1.797	1.922	2.016	2.359	2.375
Average	.875	1.229	1.464	1.667	1.854	2.026	2.151	2.354	2.698

60# Impact Load Test - Set

Specimen 1	.004	.009	.018	.029	.041	.053	.064	.079	.097
2	.007	.016	.026	.035	.036	.070	.087	.104	.128
3	.011	.008	.023	.033	.045	.054	.089	.090	.143
Average	.007	.011	.022	.032	.040	.059	.080	.091	.122

15# Impact Load Test - Deflection

Specimen 1	.250	.391	.469	.547	.578	.609	.656	.719	.719
2	.297	.422	.531	.594	.672	.703	.734	.781	.844
3	.281	.391	.500	.562	.609	.672	.703	.750	.797
Average	.276	.401	.500	.567	.619	.661	.697	.750	.786

15# Impact Load Test - Set

Specimen 1	.005	.006	.007	.007	.010	.009	.013	.015	.014
2	.002	.000	.001	-.003	-.003	.002	.006	.004	.000
3	.000	.005	.001	-.004	.001	.009	.009	.001	.006
Average	.002	.004	.003	.000	.002	.006	.009	.006	.007

OBSERVATIONS OF DAMAGE ON PANEL OAA

CONCENTRATED LOAD TEST

Specimen No. 1	Specimen No. 2	Specimen No. 3
No apparent damage.	No apparent damage.	No apparent damage.

UNIFORM LOAD TEST

Specimen No. 1	Specimen No. 2	Specimen No. 3
No apparent damage.	No apparent damage.	No apparent damage.

60# IMPACT TEST (On Gypsum board side)

Specimen No. 1		Specimen No. 2		Specimen No. 3	
HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
54"	No apparent damage.	30"	Loaded Face: Crack 2" long at one nail of simulated shelf strip.	48"	Loaded Face: Crack 20" long adjacent to simulated shelf strip.
		36"	Above crack extended to 2'.	54"	Above crack increased to 28".

15# IMPACT TEST (On Gypsum board side)

Specimen No. 1		Specimen No. 2		Specimen No. 3	
54"	No apparent damage.	54"	No apparent damage.	54"	No apparent damage.

60# IMPACT TEST (Hardboard side)

Specimen No. 1		Specimen No. 2		Specimen No. 3	
18"	Unloaded Face: Several nails pulled through gypsum board.		Not tested.	18"	Loaded Face: Nails pulled through panel at shelf strip (1/8").
24"	Loaded Face: Evidence of panel pulling away from shelf strip ($\frac{1}{4}$"). Unloaded Face: Two nails along shelf strip pulled completely away.			24"	Nails continued to pull at shelf strip (3/8").
30"	Unloaded Face: Crack 6" long directly under load parallel to short span. Loaded Face: Panel continued to pull away from shelf strip (5/8").			30"	Loaded Face: Panel pulled away from 1 x 2 perimeter strip ($\frac{1}{2}$"). Unloaded Face: Crack 12" long directly under load and crack 16" long radiating to bottom corners of panel.
36" 3"	Unloaded Face: Crack increased to 12".				
42"	Unloaded Face: An additional crack 8" long developed in				

(Continued)

(Continued)

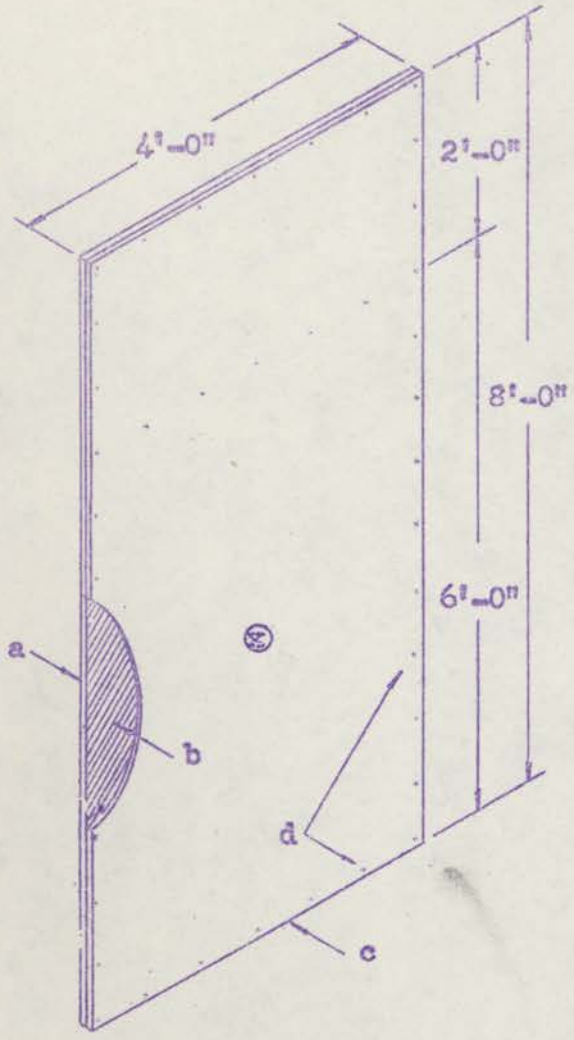
OBSERVATIONS OF DAMAGE ON PANEL OAA

Specimen No. 1		Specimen No. 2		Specimen No. 3	
HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
	No apparent damage.		Not tested.		No apparent damage.

15# IMPACT TEST (Hardboard side)

1/2" THIN WALL
1/8" untempered hardboard
and 3/8" gypsum board

TEST PANEL OI
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" untempered hardboard 4/0 x 8/0

b - Linoleum paste - 2 quarts/panel applied with a notched asphalt tile spreader.

c - 3/8" gypsum board 4/0 x 8/0 laminated to "a".

Note: Prior to installation into frame, above two layers were cemented together and pressed 24 hours with other panels or sheet material weighing 10 lbs/sq.ft. or more.

d - 6d coated box nails - 8" o.c. 1/2" minimum edge distance, fastening laminated panel onto 1" x 2" perimeter strips and shelf strip.

Built: October 20, 1951
Trade Name: U. S. G. Sheetrock (a) & (c)
Wolverine Linoleum Paste (b)

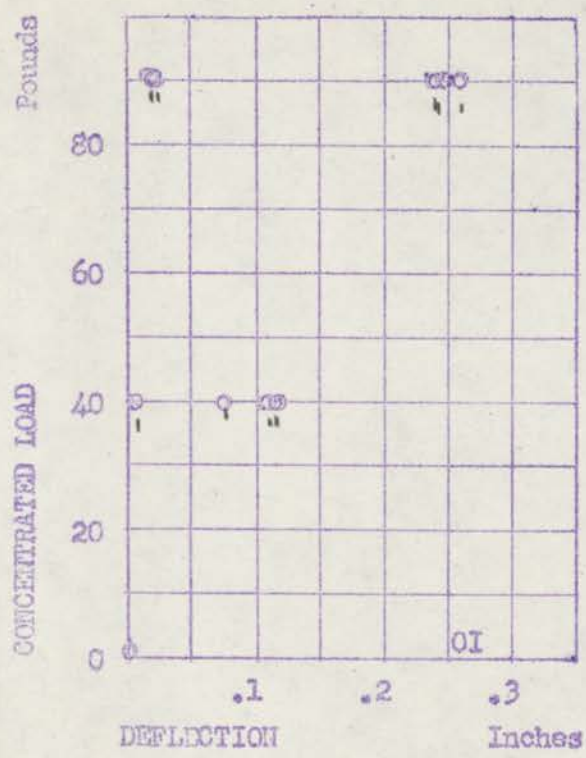
Mtls Cost/Sq.Ft.	17.8¢
Weight/Sq.Ft.	2.45#

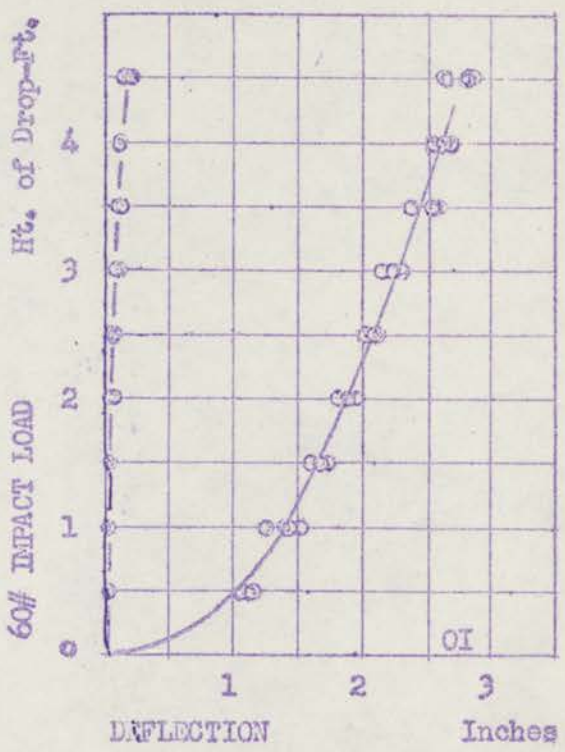
Three specimens were tested in the following sequence:

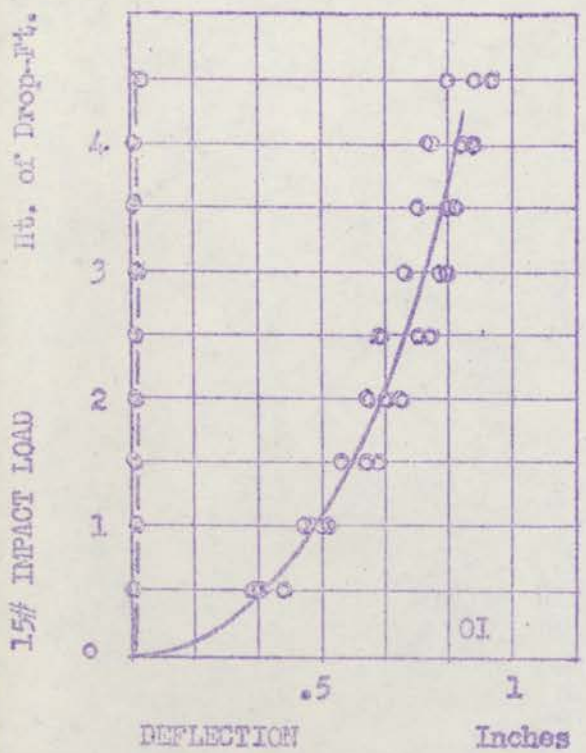
1. Uniform Load Test
2. Concentrated Load Test
3. 15" Impact Test
4. 60" Impact Test
5. 15# Impact Test (Hardboard side)
6. 60# Impact Test (Hardboard side)

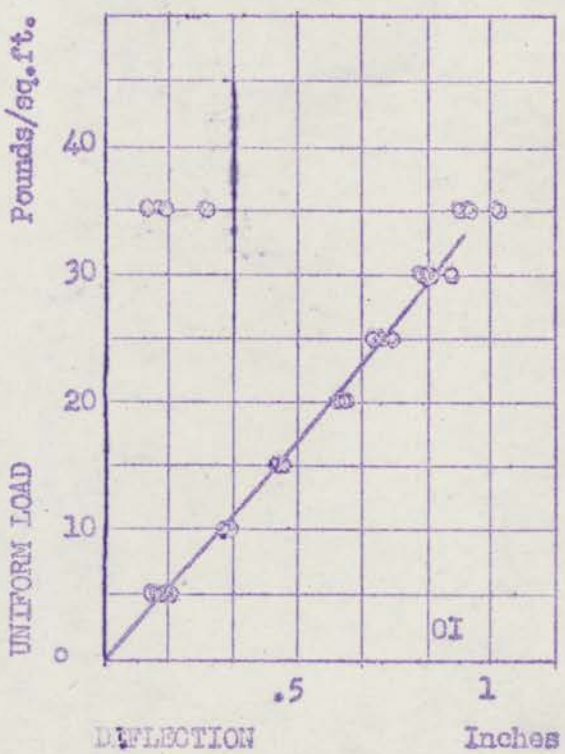
x - Indicates axis of the load.
○ - Indicates axis of the deflection.

GRAPHICAL PRESENTATION OF TEST RESULTS









Open circles: deformation under load

Solid circles: Sets after load removed

Continuous line: Load-deformation curve

Broken line: Load-set curve

TABULAR PRESENTATION OF TEST RESULTS

PANEL OI

Concentrated Load - Deflection and Indentation

	40 lbs.	90 lbs.
Specimen 1	.119	.243
2	.078	.260
3	.112	.244
Average	.103	.249

Concentrated Load - Set

Specimen 1	.008	.018
2	.007	.019
3	.008	.025
Average	.007	.020

Uniform Load Test - Deflection

Applied Load	5#/sf	10#/sf	15#/sf	20#/sf	25#/sf	30#/sf	35#/sf
Specimen 1	.125	.312	.469	.609	.703	.828	.937
2	.172	.328	.484	.609	.734	.844	.953
3	.156	.328	.484	.641	.766	.906	1.031
Average	.151	.323	.479	.620	.734	.859	.974

Uniform Load Test - Set

Specimen 1	-	-	-	-	-	-	.112
2	-	-	-	-	-	-	.160
3	-	-	-	-	-	-	.270
Average	-	-	-	-	-	-	.180

60# Impact Load Test - Deflection

Height of Drop	6"	12"	18"	24"	30"	36"	42"	48"	54"
Specimen 1	1.156	1.453	1.703	1.906	2.141	2.266	2.516	2.703	2.859
2	1.156	1.531	1.750	1.984	2.141	2.328	2.562	2.641	2.828
3	1.078	1.375	1.625	1.812	2.016	2.141	2.391	2.562	2.641
Average	1.130	1.453	1.693	1.900	2.099	2.245	2.490	2.635	2.776

60# Impact Load Test - Set

Specimen 1	.034	.038	.047	.078	.091	.176	.164	.198	.260
2	.023	.029	.043	.039	.046	.064	.075	.101	.148
3	.019	.032	.050	.061	.074	.086	.108	.123	.152
Average	.025	.033	.046	.059	.070	.108	.115	.140	.186

15# Impact Load Test - Deflection

Specimen 1	.344	.500	.625	.672	.766	.812	.828	.875	.906
2	.406	.515	.656	.719	.781	.828	.859	.906	.953
3	.328	.469	.562	.625	.656	.734	.766	.797	.828
Average	.359	.494	.614	.672	.734	.791	.817	.859	.896

15# Impact Load Test - Set

Specimen 1	.000	.002	.001	.012	.011	.031	.008	.013	.013
2	.008	.009	.009	.009	.010	.010	.013	.017	.022
3	.005	.010	.003	.005	.002	.002	.005	.003	.020
Average	.004	.007	.004	.008	.006	.014	.008	.011	.018

OBSERVATIONS OF DAMAGE ON PANEL OI

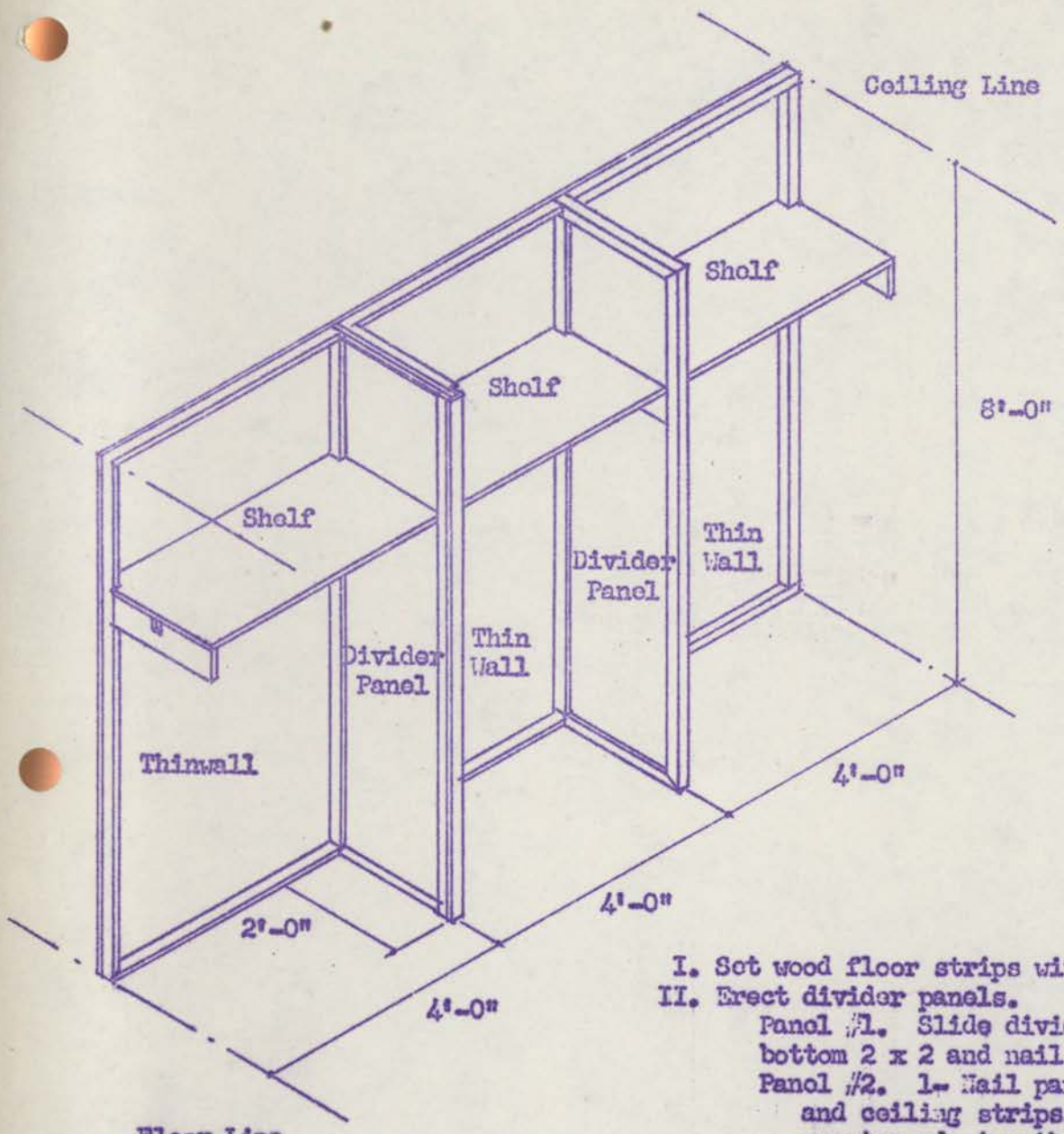
	Specimen No. 1	Specimen No. 2	Specimen No. 3
CONCENTRATED LOAD TEST	No apparent damage.	No apparent damage.	No apparent damage.
UNIFORM LOAD TEST	No apparent damage.	No apparent damage.	No apparent damage.
60# IMPACT TEST			
Ht of Drop	REMARKS	Ht of Drop	REMARKS	Ht of Drop	REMARKS
36"	Loaded Face: Slight creases in gypsum board 12" long radiating from bottom corners of panel.	54"	Loaded Face: Crease 18" long along shelf strip. Two creases 12" long also developed radiating from bottom corners of panel to point of impact.	48"	Loaded Face; Slight creases radiating from bottom corners of panel to point of impact.
48"	Above creases increased to 18". Crease also developed 12" long radiating from shelf strip.				
15# IMPACT TEST	No apparent damage.	No apparent damage.	No apparent damage.
15# IMPACT TEST (Hardboard Side)			
42"	Panel face pulled slightly through nails.	Not tested.	Not tested.
60# IMPACT TEST (Hardboard Side)			
6"	Unloaded Face: 2 nails pulled slightly on shelf strip.	Not tested.	12" Unloaded Face: Nails were pulled into gypsum board on shelf strip 1/8".
18"	Unloaded Face: 2 more nails pulled at shelf strip. Loaded Face: Panel pulled away from shelf strip ½".		24" Unloaded Face: Crack 8" long devoloped in the gypsum board radiating diagonally from lower corner.

(Continued)

OBSERVATIONS OF DAMAGE ON PANEL OI

Specimen No. 1		Specimen No. 2		Specimen No. 3	
60# IMPACT TEST (Hardboard side)					
HT of Drop	REMARKS	HT of Drop	REMARKS	HT of Drop	REMARKS
30"	Loaded Face: Panel pulled away from shelf strip and additional ¼ to ½". Unloaded Face: Nails at shelf strip pulled through completely at crack developed 1' long.			30"	Above crack increased to 12" and another crack 12" long developed radiating from opposite corner.

CLOSET #1 ASSEMBLY



I. Set wood floor strips with Anchors. (a)

II. Erect divider panels.
- Panel #1. Slide divider panel into bottom 2 x 2 and nail.
- Panel #2. 1- Nail panel to 1 x 2 floor and ceiling strips. 2- Nail 1/2" quarter rd. to other side of panel.

III. Install ceiling cleats.
- A. 2 x 2 with 10d casing nails 8" o.c.
- B. 1 x 2 with 8d casing nails 8" o.c.

IV. Attach shelf cleats to side walls (none on back walls).

V. Insert clothes poles into notched 1 x 6 shelf cleats.

VI. Install shelves.
Nails 2-1/2" o.c.

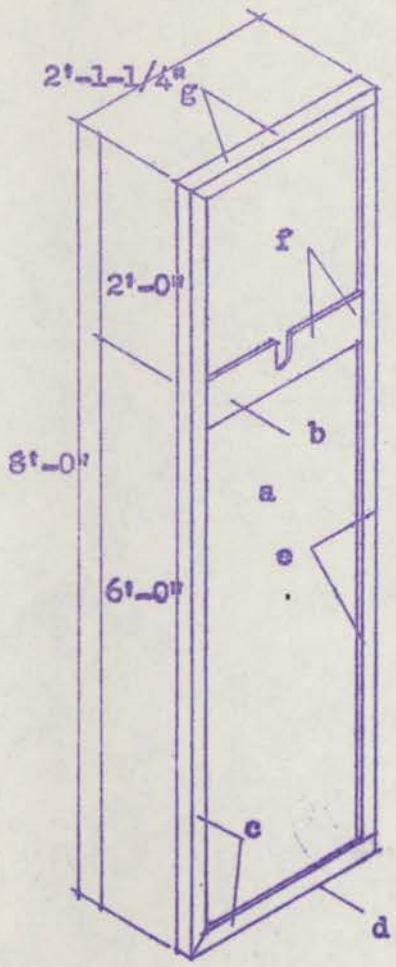
VII. Erect back panels (use 3 thin wall panels, 1/8" hardboard laminated to 3/8" gypsum board, 2 qts. linoleum paste)
- A. Nail back panels to ceiling and floor cleats and divider panel stiffeners.
- B. Blind nail through back partitions into shelves 6" o.c. - all compartments.

VIII. Tape Joints

(a) Acramen Johnson

FRAMED DIVIDER PANEL
NO TRIM

PANEL #1
CLOSET WALL PROJECT
L.D.R.C.



a - 1/8" tempered hardboard smooth two sides - 2'0" wide and height 1-1/4" less than ceiling height.

b - 1" x 6" shelf strip with notch for clothes pole.

c - 2" x 2" rabbeted with 9.3/64" x 1" groove. #2 and better yellow pine.

d - 1/4" bolt screwed into expansion anchor set in concrete (2 per strip).

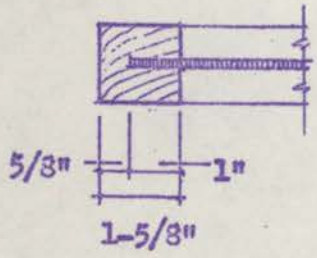
e - 4d casing nails 6" o.c. with alternate nails thru opposite sides.

f - 4d casing nails, 12 thru each side.

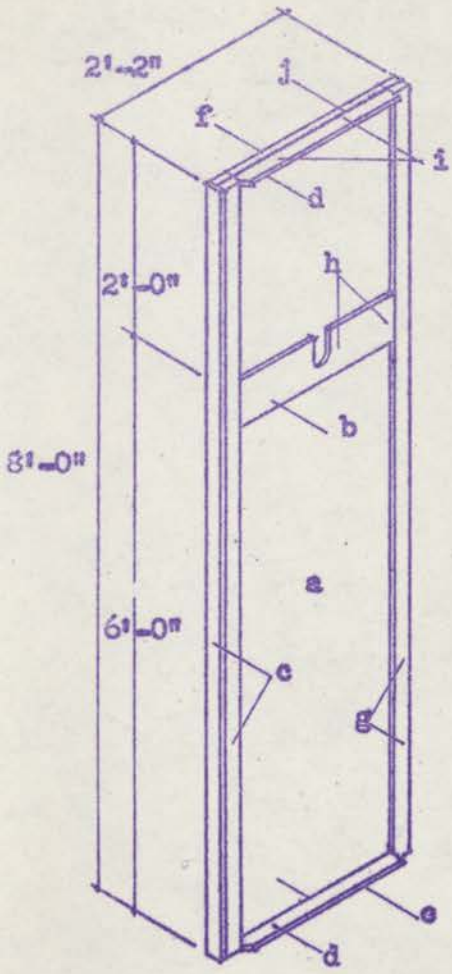
g - 10d casing nails to fasten (b) to ceiling framing - 3 on each side.

Built: December 1, 1951

Trade names: Duxon - by U.S.G. (a)



STIFF-EDGED DIVIDER PANEL



PANEL #2
CLOSET WALL PROJECT
L.D.R.C.

a - 1/8" tempered hardboard smooth 2 sides - 2' 0" wide and height 1-1/4" less than ceiling height.

b - 1" x 6" shelf strip with notch for clothes pole.

c - 1" x 2" edge stiffeners - three on front and two on back edge of panel.

d - 1" x 2" floor and ceiling strip.

e - 1/4" bolt screwed into expansion anchor set in concrete. (2 per strip)

f - 1/2" quarter round at floor and ceiling.

g - 4d casing nails 6" o.c. with alternate nails thru opposite sides.

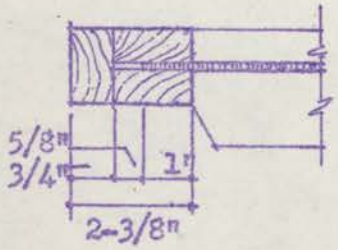
h - 4d casing nails - 12 thru each side.

i - 10d casing nails to fasten (c) to ceiling framing - 3 on each side.

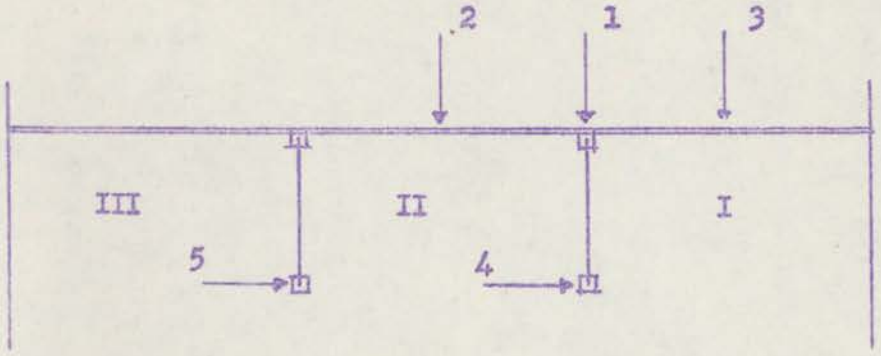
j - 2 box nails to fasten hardboard to 1" x 2" floor and ceiling.

Built: December 1, 1951

Trade names - Duron by U.S.G. (a)



COMPLETE CLOSET



CLOSET #1
Test Sequence

The complete closets received 60# sandbag impact test in the following sequence:

1). On the back of divider No. 1 - 3'-0" height, 3" increments, 36" maximum drop.

2). On the back of the back wall panel of compartment No. II - 3'-0" height, 6" increments, 36" maximum drop.

3). On the back of the back wall panel of compartment No. I - 3'-0" height, 6" increments, 36" maximum drop.

4). On the side of the front post of divider No. 1 - 3'-0" height, 1" increments, 18" - 24" maximum drop.

5). On the side of the front post of divider No. 2 - 3'-0" height, 1" increments, 13" maximum drop.

TEST RESULTS - CLOSET NO. 1

60# Impact Load - Test No. 1

Height of Drop	Deflection	Residual Deflection
3 inches	.016	.016
6	.070	.055
9	.109	.078
12	.141	.086
15	.141	.086
18	.149	.086
21	.133	.094
24	.172	.094
27	.180	.109
30	.234	.117
33	.274	.141
36	.274	.149

60# Impact Load - Test No. 2

6	.906	.000
12	1.109	.016
18	1.359	.016
24	1.687	.031
30	1.812	.047
36	1.875	.047

60# Impact Load - Test No. 3

6	1.000	.016
12	1.344	.047
18	1.516	.047
24	1.641	.062
30	1.891	.109
36	2.125	.141

TEST RESULTS - CLOSET NO. 1

60# Impact Load - Test No. 4

Height of Drop	Deflection	Residual Deflection
1 inches	.594	.016
2	.766	.031
3	1.031	.031
4	1.234	.039
5	1.250	.047
6	1.234	.047
7	1.500	.047
8	1.500	.047
9	1.625	.062
10	1.672	.062
11	1.859	.078
12	2.000	.078
13	2.062	.094
14	2.078	.094
15	2.109	.094
16	2.250	.109
17	2.297	.125
18	2.500	.125
24	2.844	-

60# Impact Load - Test No. 5

1	.641	-
2	.906	.024
3	1.008	.031
4	1.172	.047
5	1.359	.086
6	1.711	.125
7	1.914	.149

TEST RESULTS - CLOSET NO. 1

60# Impact Load - Test No. 5

Height of Drop	Deflection	Residual Deflection
8 inches	No Drop	
9	1.836	.164
10	2.109	.203
11	2.242	.242
12	2.250	.234
13	2.367	.266

OBSERVATIONS OF DAMAGE ON CLOSET NO. 1

60# SWINGING SAND BAG IMPACT TEST

Test No. 1

Test on back of divider No. 1

36" Drop	No apparent damage.

Test No. 2

Test on back of the back wall panel of compartment No. 2.

24" Drop	Loaded Face: Taped joint cracked in five places. Cracks ranged in length from 2 to 12".
30" Drop	The above cracks lengthened.
36" Drop	The above cracks increased resulting in cracks in the wallboard at edge of tape.

Test No. 3

Test on back of back wall panel of compartment No. 1

24" Drop	Loaded Face: Two cracks developed at taped joint 9" and 18" in length.
30" Drop	The above cracks increased extending into one another resulting in one long crack 30" long. Depth of crack 1/16".

Test No. 4

Test on side of the front post of divider No. 1.

24" Drop	2 x 2 floor strip sheared off at depth of rabbet (pronounced at front of divider panel). Serious crack resulted in the masonite radiating from the corner.

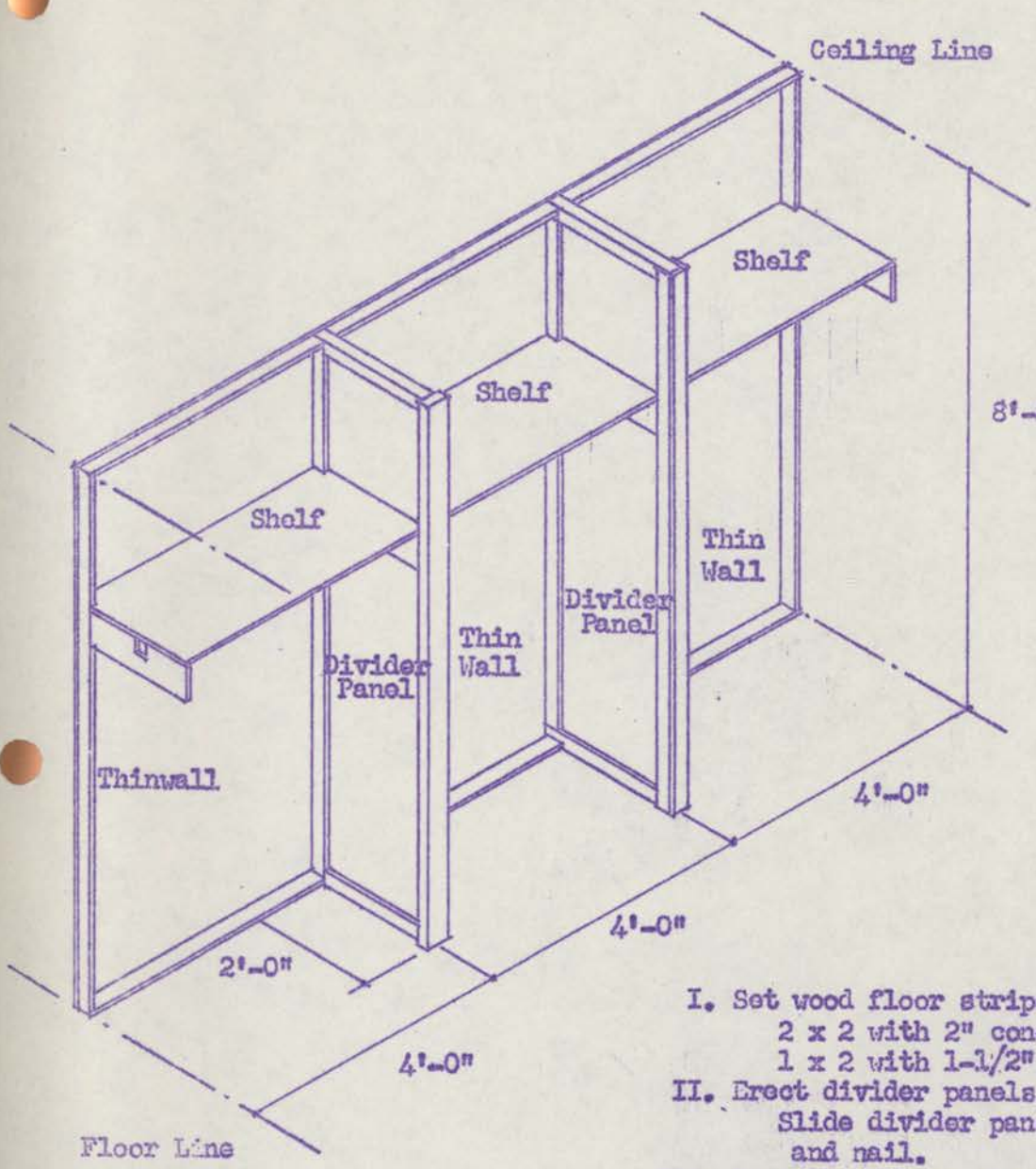
Test No. 5

Test on the side of the front post of divider No. 2.

6" to 14" Drop	Front post gradually bowed 1/4" at the point of impact, while the foot and top were gradually dislocated 3/8" in the opposite direction.

COMPLETE CLOSET

CLOSET #2 ASSEMBLY



I. Set wood floor strips.
   2 x 2 with 2" concrete nails.
   1 x 2 with 1-1/2" concrete nails.

II. Erect divider panels.
   Slide divider panels into bottom 2 x 2 and nail.

III. Install ceiling cleats.
   A. 1 x 2 with 8d casing nails 8" o.c.

IV. Attach shelf cleats to side walls.
   (None on back walls).

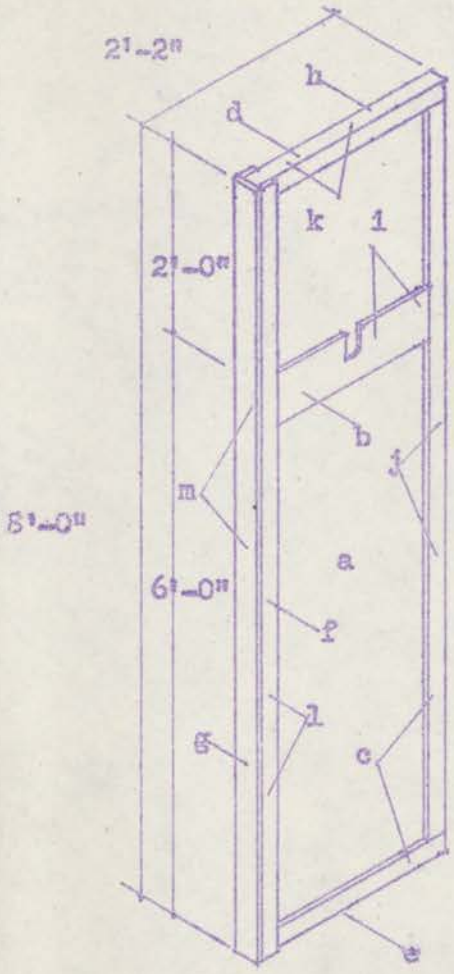
V. Insert clothes poles into notched 1 x 6 shelf cleats.

VI. Install shelves
   Nails 2-1/2" o.c.

VII. Erect back panels (use 3 thinwall panels, 1/8" hardboard laminated to 3/8" gypsum board 2 qt. linoleum paste).
   Nail back panel to ceiling and floor cleats and divider panel stiffeners.
   Blind nail through back partition into shelves 6" o.c. all compartments.

VIII. Tape joints.

FRAMED DIVIDER PANEL WITH TRIM



PANEL #3
CLOSET WALL PROJECT
L.D.R.C.

a - 1/8" tempered hardboard smooth two sides 2' 0" wide and height 1-1/4" less than ceiling height.

b - 1" x 6" shelf strip with notch for clothes pole.

c - 2" x 2" rabbeted with 9 3/64" x 1" groove. #2 and better yellow pine.

d - shingle wedges to hold panel.

e - 2" concrete nails, 3 on each side.

f - 1/2" x 1-5/8" white pine trim.

g - 3/4" x 2-5/8" white pine trim.

h - 3/4" quarter round at ceiling.

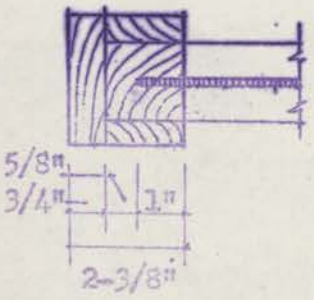
i - 4d casing nails, 10 thru each side.

j - 4d covering nails 3" o.c. with alternate nails thru opposite sides.

k - 10d casing nails fastened (c) to ceiling framing - 3 on each side.

l - 4d casing nails 6" o.c.

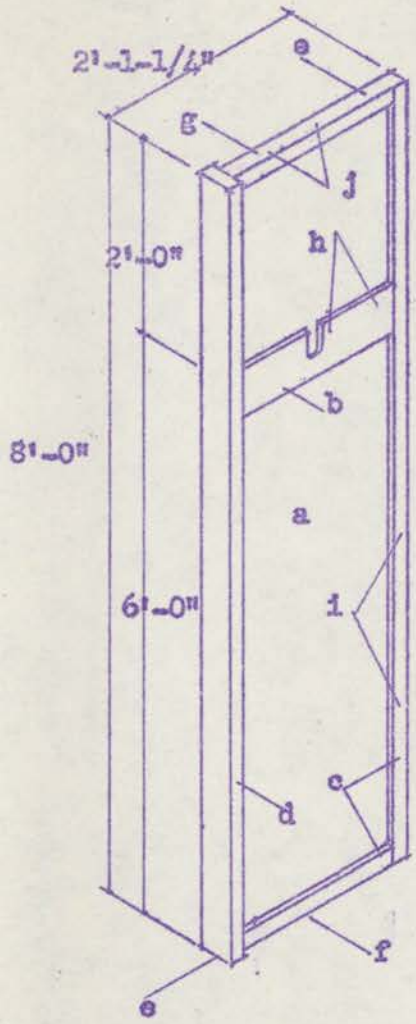
m - 6d casing nails 12" o.c.



Built: December 8, 1951

Trade Names: Duron by U.S.G. (a)

FRAMED DIVIDER PANEL WITH HEAVY FRONT POST



PANEL #4
CLOSET WALL PROJECT
L.D.R.C.

a - 1/8" tempered hardboard smooth two sides - 2'-0" wide and height 1-1/4" less than ceiling height.

b - 1" x 6" shelf strip with notch for clothes pole.

c - 2" x 2" rabbeted with 9.3/64" x 1' groove. #2 and better yellow pine.

d - 2" x 4" rabbeted with 9.3/64" x 1" groove.

e - Shingle wedges to hold panel.

f - 2" concrete nails - 3 on each side.

g - 3/4" quarter round at ceiling.

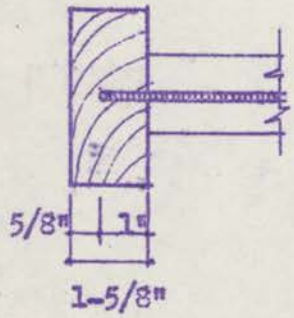
h - 4d casing nails, 10 thru each side.

i - 4d casing nails, 6" o.c. alternate nails thru opposite sides.

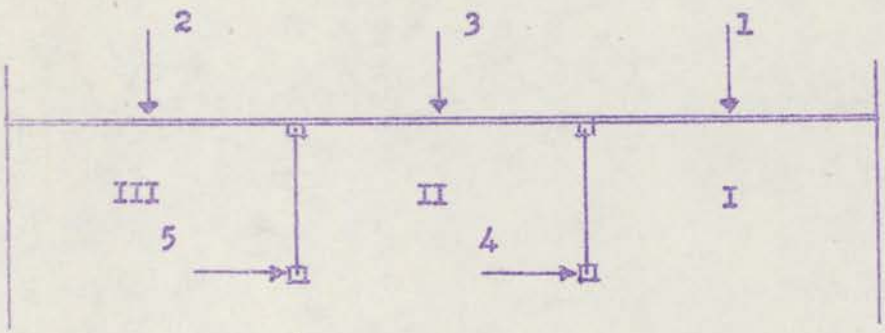
j - 10d casing nails to fasten (c) to ceiling framing - 3 on each side.

Built: December 8, 1951

Trade names: Duron by U.S.G. (a)



COMPLETE CLOSET



CLOSET #2

Test Sequence

The complete closets received 60# sandbag impact tests in the following sequence:

1). On the back of the back wall panel of compartment No. I - 3'-0" height, 3" increments 24" maximum drop.

2). On the back of the back wall panel of compartment No. III - 3'-0" height, 3" increments, 36" maximum drop.

3). On the back of the back wall panel of compartment No. II - 3'-0" height, 3" increments, 36" maximum drop.

4). On the side of the front post of divider No. 3 - 3'-0" height, 1" increments to 15" - 21" maximum drop.

5). On the side of the front post of divider No. 4 - 3'-0" height, 1" increments to 15" - 21" maximum drop.

TEST RESULTS - CLOSET NO. 2

60# Impact Load - Test No. 1

Height of Drop	Deflection	Residual Deflection
3 inches	.562	.016
6	.797	.016
9	1.000	.016
12	1.156	.016
15	1.266	.016
18	1.532	.031
21	1.563	.031
24	1.687	.031

60# Impact Load - Test No. 2

3	.500	.000
6	.812	.000
9	.875	.000
12	1.031	.000
15	1.188	.016
18	1.328	.016
21	1.360	.016
24	1.515	.016
27	1.641	.031
30	1.688	.031
33	1.703	.031
36	1.860	-

60# Impact Load - Test No. 3

3	.609	.000
6	.891	.000
9	1.016	.000
12	1.109	.000
15	1.250	.000
18	1.359	.016

TEST RESULTS - CLOSET NO. 2

60# Impact Load - Test No. 3

Height of Drop	Deflection	Residual Deflection
21 inches	1.422	.016
24	1.562	.016
27	1.531	.031
30	1.562	.031
33	1.875	.031
36	1.937	.031

60# Impact Load - Test No. 4

1	.328	.000
2	.453	.000
3	.594	.016
4	.625	.000
5	.766	.016
6	.797	.016
7	.875	.031
8	.984	.031
9	1.062	.031
10	1.109	.031
11	1.219	.062
12	1.266	.078
13	1.344	.062
14	1.391	.062
15	1.516	.078
18	1.656	.094
21	1.844	.109

60# Impact Load - Test No. 5

1	.219	.000
2	.297	.016
3	.297	.016

TEST RESULTS - CLOSET NO. 2

60# Impact Load - Test No. 5

Height of Drop		Deflection	Residual Deflection
4 inches		.391	.016
5		.469	.016
6		.547	.031
7		.500	.031
8		.594	.031
9		.641	.031
10		.703	.031
11		.687	.031
12		.781	.031
13		.875	.047
14		.906	.047
15		.953	.062
18		1.203	.078
21	Failure	1.453	

OBSERVATIONS OF DAMAGE ON CLOSET NO. 2

60# SWINGING SAND BAG IMPACT TEST

Test No. 1

Test on the back of the back wall panel of compartment No. 1.

15" Drop	Loaded Face: Very minute cracks in taped joint. (Cracks could be corrected by paint).
18" Drop	The above cracks increased in increments of 4".
21" Drop	The above cracks showed no appreciable increase in length; however, the severity of the impact caused the cracks to open to a point almost beyond repair, i.e. a new panel would possibly be needed.
24" Drop	Additional opening of the cracked joint.

Test No. 2

On the back of the back wall panel of compartment No. 3.

15" Drop	Loaded Face: Hairline crack 2' in length along edge of tape. Paint could correct.
18" Drop	The above crack increased 4" in length, no increase in width of crack.
24" Drop	The above crack increased 6" in length.
36" Drop	Slight opening of the crack patching plaster could repair.

Test No. 3

On back of back wall panel of compartment No. 2.

36" Drop	Loaded Face: Hairline crack developed as an extension of previous damage from tests 1 and 2. Maximum length of extension 6".

Test No. 4

Test on the side of the front post of divider No. 3.

24" Drop	Trim at front edge of divider cracked, 2 x 2 remained undamaged.

OBSERVATIONS OF DAMAGE ON CLOSET NO. 2

60# SWINGING SAND BAG IMPACT TEST
Continued

Test No. 5

Test on the side of the front post of divider No. 4.

18" Drop	Bottom of 2 x 4 displaced 1/8" (movement enough to impair door installation).
21" Drop	2 x 4 displaced 1". Last 3" of rabbeted 2 x 2 cracked off. Hardboard cracked diagonally from the corner, concrete nails held securely.